DEVOTED EXCLUSIVELY TO METALLIC SURFACE TREATMENTS

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CONTENTS

Editorial 45
Electroplating Magnesium and Its Alloys 46
By H. K. De Long
Throwing Power of Electroplating Solutions 50
By A. Mankowich
Fluid Mechanics: Forgotten Factor in Electroplating—Part III 55
By Joseph B. Kushner
Surface Finishing Automobile Moldings 60
By L. F. Strong
The Mechanism of Exfoliation of Electrodeposited Surfaces 62
By A. T. Steer
Demineralization of Water 71
By Dr. F. R. Morral
Shop Problems 73
Engineering Data Sheet 75
Patents 76
Recent Developments 79
Business Items 89
Manufacturers' Literature 96
News from California 101
Associations and Societies 103

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COMING SOON

A report on the relative protection afforded by various types of sealing treatments for anodized coatings on aluminum alloys.

Production of a diffusion type chromium surface on steel for engineering uses. The process does not involve electrochemical methods.

A discussion of the importance of correct bath balance on the protective qualities of phosphate coatings on steel.

Methods for determining the more important physical properties of electrodeposited coatings, with a discussion of the practical significance of the test results.

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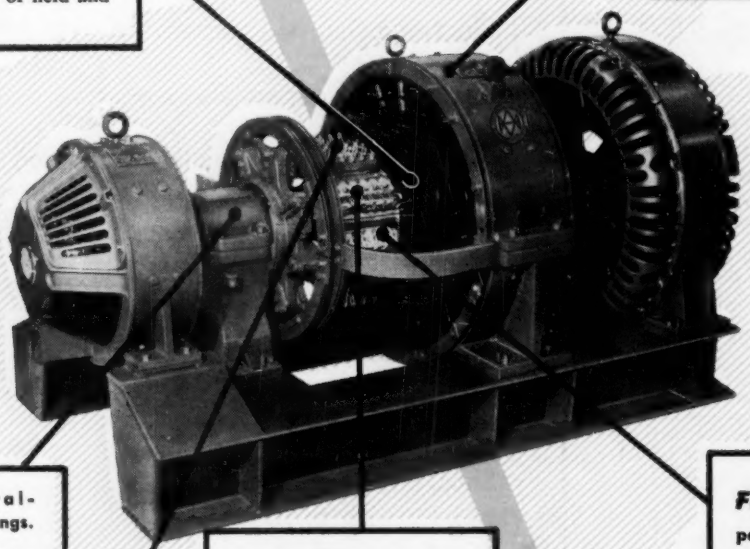
ADVANTAGES: More efficient conductor of magnetism than *any* casting. Ring set within frame to lower center of gravity, reducing vibration to a minimum.



FEATURE: Liberal-sized sleeve-type bearings.

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FEATURE: Moulded-in "Equaload" shunts.

ADVANTAGES: Equal load distribution among brushes assured by special alloy shunts. Moulded-in shunt reduces resistance inherent when attached to brush by other methods.

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METAL FINISHING

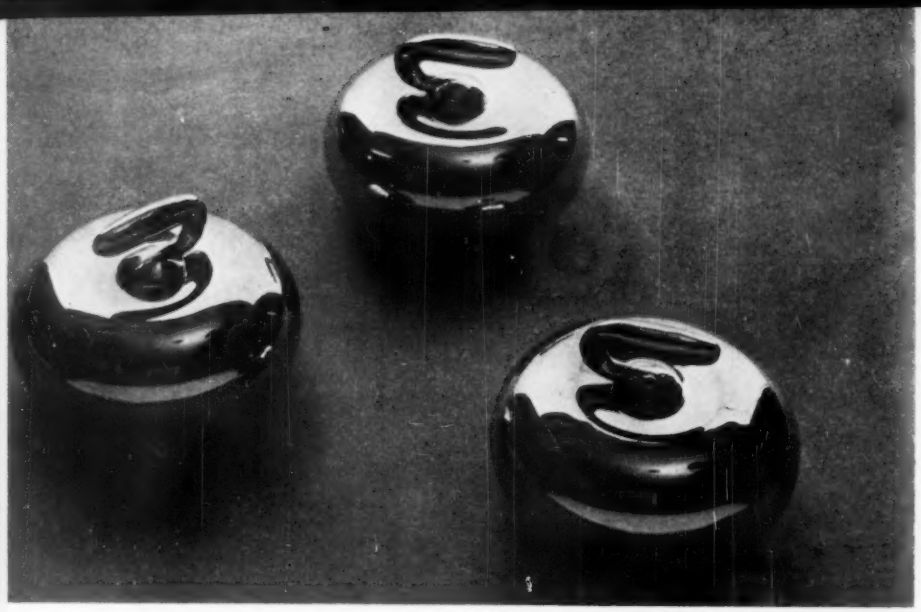
Hats Off to the NAMF

Contract, or "job" plating shops occupy an important and unique position in the metal finishing field. The problems inherent in successful job-shop operation are far more involved than is customarily realized.

Subject to unusually rapid fluctuations in business activity as a result of the customers they serve, the job-shops are, as a rule, unable to take advantage of many of the cost-reducing methods available to other types of shops, such as large quantity purchasing of supplies, mechanized processing equipment, or scheduled production. Yet they are required to quote prices for their services that compare favorably with those of shops operating with these advantages in their favor.

To do this without sacrificing quality standards, jobbing shops must continually strive to make each operation as efficient as possible, and the important position of job-shops in the metal finishing picture is a high tribute to the business ability of their operators.

A major factor in promoting and maintaining successful operation in this field is the valuable work being done by the National Association of Metal Finishers. Through their reports and assistance to members on such questions as costs, labor relations, and technical problems, this organization is rendering an outstanding service to the industry, and we can look forward to many new and significant developments toward lower finishing costs to come from the job-shop branch of the metal finishing field.



Electroplating Magnesium and Its Alloys

By H. K. DeLong, *Dow Chemical Co., Midland, Mich.*

Introduction

ATTEMPTS in the past to develop a successful process for electroplating on magnesium and its alloys have been, in general, quite discouraging. Factors such as the position of magnesium in the electrochemical series, along with its nature of being quite active in many neutral and most acid solutions, and its filming characteristics being such that hydroxide forms on the surface in almost any aqueous solution before metal ions can be deposited, have had to be dealt with and overcome.

Various methods have been advanced and are mentioned in the patent literature for obtaining electrodeposits in both aqueous and nonaqueous media.[1] Experimental evaluation of these processes did not indicate much hope for their large-scale success, primarily because of insufficient adhesion of the deposits to the base metal. The nearest approach to the development of a commercially feasible process was achieved by *Loose* through application of nickel from a nickel fluoborate type bath after etching and treating the surface in hydrofluoric acid.[2] This process gave adherent nickel deposits in small-scale operation, but was difficult to control, and impractical when attempts were made to use it on a larger scale.

Development of Zinc Coating Process

A new process has been developed and has been thoroughly investigated through laboratory tests and pilot plant operations for electroplating on magnesium. With this process, any of the metals that are capable of being electrodeposited can be applied to magnesium in a very adherent manner. In general, the process consists in the initial application of an immersion zinc coating followed by copper striking and electroplating in standard plating baths.

Magnesium, being less noble than any of the common metals, readily replaces many of them from solutions of their salts. In acid solutions, the immersion coatings are very nonadherent and powdery, while in strongly alkaline solutions, the coatings are more adherent but insufficiently so as to afford a base for electrodeposits. Most alkaline compounds, with the exception of pyrophosphates, do not attack magnesium. It was through the discovery that pyrophosphates did react with magnesium that the present method of zinc coating magnesium was possible. Pyrophosphates will readily dissolve oxide and hydroxide coatings from magnesium and actually brighten the surface. By the addition of certain zinc salts to the pyrophosphate solutions, an adherent zinc film was formed. The quality of the zinc immersion deposit, it was found, was dependent to a marked extent on the rate of deposition and also the ratio of zinc to pyrophosphate. Too rapid a rate of deposition caused less adherent coatings to form and, therefore, various inhibiting salts were added to control the reaction rate. It was found that flourides in small amounts were very effective and gave a much finer-grained zinc coating. The pH of the zinc bath was also a consideration as was the use of carbonates in adjusting and maintaining this factor in the proper range

A very suitable solution for applying the zinc immersion coating by the pyrophosphate-zinc method

has the following composition and operating characteristics:

120 grams/liter tetrasodium pyrophosphate ($Na_4P_2O_7$)
40 grams/liter zinc sulphate ($ZnSO4.7H_2O$)
10 grams/liter potassium fluoride (KF)
5 grams/liter potassium carbonate (K_2CO_3)

Treatment time = 3-5 minutes
Operating Temperature = 175-185° F.
pH = 10.0-10.4
Solution mildly agitated.

The reactions that occur in this bath are quite interesting when observed on a thinly oxide-coated magnesium surface. Upon the introduction of such a coated magnesium piece into it, there is an immediate evolution of gas and a brightening of the surface due to the oxide removal. Once the surface is free of oxide, the zinc film starts to form and the surface gradually acquires a typical blue-gray color of the zinc. After a continuous zinc coating is formed, the gas evolution subsides to a point where little reaction is noted. The fact that the reaction ceases indicates that a continuous coating has been formed and no further build up of the zinc will occur. The coating thus formed is extremely thin, and although it it has not been accurately measured, is known to be less than 0.0001″ in thickness. X-ray diffraction analysis of the coating formed by this bath shows it to be pure metallic zinc.

In the zinc immersion treatment bath, the chemical compounds and concentrations, with the exception of the fluoride, are not exceptionally critical. The fluoride is added, as previously mentioned, to reduce the rate of immersion deposition on the magnesium surface. While good deposits have been obtained in fluoride-free baths on some alloys, the conditions of time and temperature are very critical. In general one per cent potassium fluoride or 0.75% sodium fluoride give optimum conditions for all the commercial alloys. If a greater percentage of fluoride is added, the rate of immersion deposition is retarded to too great an extent. It can be completely stopped when about five per cent is present. Either sodium or potassium pyrophosphate may be used and in percentages of 6 to 24 per cent. No ammonium salts are permissible in this bath as the presence of ammonia tends to produce less adherent deposits. Zinc fluoride, and zinc cyanide also have been used to provide the zinc ion content, but are not quite as satisfactory on the higher aluminum content alloys. The actual temperature of the bath may vary from room temperature to boiling, although maximum adhesion and freedom from subsequent blistering is obtained at temperatures above 170° F. and preferably at 175-185° F. The zinc bath has a relatively long useful life and depletes quite slowly in pyrophosphate and zinc. The bath can be analyzed and replenished by additions of these compounds. The fluoride is lost primarily by drag-out and need be added only at infrequent intervals. Carbonate is required only as a means of pH adjustment. The presence of heavy metal salts, other than zinc, in the bath must be kept at a minimum. Chromium salts are particularly detrimental as they tend to inhibit the zinc coating formation if present in quantities greater than a few hundredths of one per cent. It is therefore advisable to use de-ionized or distilled water and good commercial grade chemicals for making up and adding to this solution.

Electroplating Procedure

In the foregoing we have discussed the functions of the zinc immersion bath in detail, since it is the key to the success or failure of the subsequent electroplating operation. It, of course, is not the first step in applying electrodeposits to magnesium and must be preceded by proper degreasing and pickling steps to secure a clean and homogenous surface as in plating upon other metals.

Preliminary Surface Preparation

The surface must be free of non-metallic contamination such as the normal oxide or hydroxide coatings, inclusions of oxide, millscale, dirt, forming lubricants, previously applied chemical treatment coatings, oil, grease, etc. To insure the removal of foreign materials of these varied natures, the parts are first degreased and pickled prior to mechanical operations such as buffing. The pickling also tends to remove from the surface intermetallic compounds and precipitates which primarily occur in castings. It is particularly important to pickle parts that are not buffed, or are not buffed over-all, so as to prepare the unbuffed surface for zinc coating. To obtain a satisfactory surface condition, cast parts are pickled in 75-85% phosphoric acid, while wrought parts are pickled in 20% acetic acid + 5% sodium nitrate. The pickling is carried out at room temperature (70-90° F.) and pickling times of one to three minutes are required.

In many cases it may not be necessary to give the preliminary pickle to magnesium parts as indicated above. Parts that are reasonably free of non-metallic inclusions and are to be polished or buffed over-all, may not require it. Photoengraved magnesium alloy printing plates do not usually require pickling prior to electroplating unless the plates have been stored and noticeably oxide coated after etching in the photoengraving process. In cleaning magnesium in this application where little dimensional change or even minor loss of detail can be tolerated, the parts are immersed in 18% chromic acid for two to five minutes at room temperature. This pickling operation is followed by water rinsing and then by dipping in 15% hydrofluoric acid for three to five minutes at room temp. to remove any chromium films. The hydrofluoric and chromic acid dips cause little or no dimensional change.

Mechanical Operations

After the pickling operations, if a smooth highly polished surface is desirable, the parts are wheel polished and buffed. In case of small parts tumbling and burnishing operations may be used. Where blasting operations are used, such operations should precede the preliminary pickling. Blasting leaves a sur-

face that is highly reactive and not suitable for plating, unless pickled afterwards.

Precleaning

After the parts have been prepared as has been previously described, the following cleaning steps are required before electroplating:

A. Solvent degrease by any of the common methods such as vapor degreasing, solvent emulsion cleaning, etc., if buffing compound, heavy oil, or grease films are present on the surface.

B. Soak clean for three to five minutes at 180-212° F. in an aqueous alkaline cleaning solution containing 8 oz./gallon (6%) trisodium phosphate ($Na_3PO_4.12 H_2O$). Anodic cleaning for 10-20 seconds in this solution at 6V. at the end of the soak cleaning period is optional, but preferable. The anodic cleaning should not be prolonged, as the surface will become hydroxide coated due to anodic oxidation and will require a longer subsequent pickling time to break down this coating.

C. Pickle for 15 seconds to 1½ minutes in 1% hydrochloric acid (HCl). This pickle tends to activate the surface after alkaline cleaning. It should be for sufficient time to insure a uniform etching of the surface so that local passive areas are broken down and do not interfere with obtaining a uniform zinc coating. 1% acetic acid ($CH_3.COOH$) appears to be more suitable for the magnesium-1.5% manganese alloy, although it is not required to obtain uniform and adherent zinc coatings on this alloy.

Zinc Immersion Coating

The zinc immersion coating previously described in detail, is applied next. Parts should be rinsed in cold water only after the zinc immersion treatment. Do not use a hot water rinse.

Copper Strike

Copper strike the zinc coated parts immediately after cold water rinsing in a Rochelle Salt type copper cyanide bath of the following composition:

5.5 oz./gal. (41.3 gms./liter) copper cyanide
6.8 oz./gal. (50.8 gms./liter) sodium cyanide
4.0 oz./gal. (30.0 gms./liter) sodium carbonate (soda ash)
6.0 oz./gal. (45.0 gms./liter) Rochelle Salts
0.25 oz./gal. (1.9 gms./liter) sodium thiosulphate (hypo)

Free cyanide = 0.75 oz./gal. (5.6 gms./liter)
pH = 10.0-11.0 (preferably adjusted to 10-10.5)
Temperature = 115-120° F.

Electrical contact is made quickly and a low current density of 5-10 A./ft.² is applied for the first two to three minutes. Initial high current density striking is avoided as it is apt to cause inferior adhesion and possible subsequent blistering on high current density areas of the work. After the two to three minutes of deposition, the current density is increased to 15-20 A./ft.² and plating continued for at least five minutes.

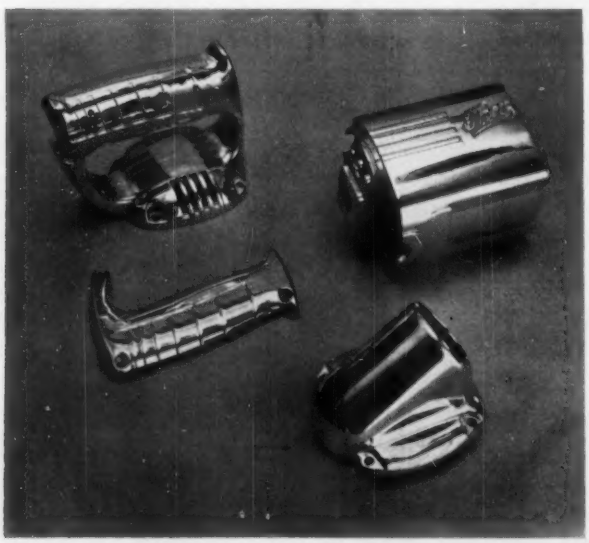


Figure I—Typical die cast magnesium alloy parts that have been copper-nickel-chrome plated by the new Dow process.

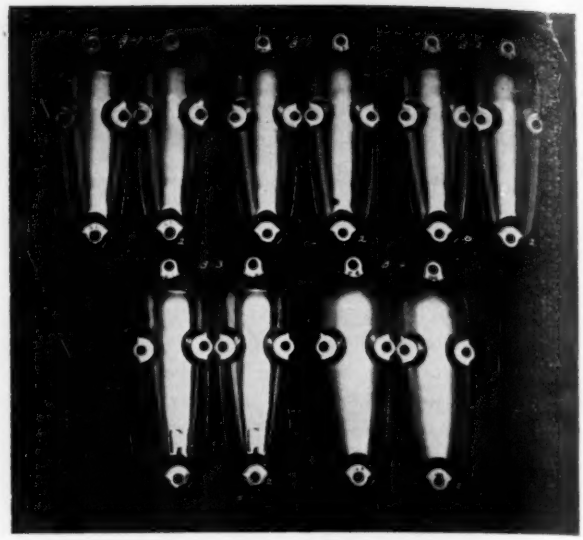


Fig. II—Copper-Nickel-Chrome plated magnesium die-cast parts after 120 hours in 20% Salt Spray test at 95°F. Total plate thickness as follows: A1 = 0.0005", B1 = 0.0010", B2 = 0.00125", B3 = 0.0015", B4 = 0.002". Samples B3 were buffed after nickel plating.

Copper Plating

Copper can be plated in heavier deposits by prolonging the time in the Rochelle Salt bath, or by transferring the work to other alkaline copper cyanide or pyrophosphate baths. Proprietary bright copper plating baths are quite satisfactory for building up the copper thickness. The duPont High Speed Copper Plating Bath has been satisfactory, and good results have also been obtained with the MacDermid Bright Copper. The Unichrome Copper Pyrophosphate Bath must be modified by the addition of 4-8 oz./gal. potassium fluoride for best results, particularly on complicated shaped parts. The latter solution tends to attack magnesium, and unless the parts are completely covered with copper from the strike or fluoride is added to inhibit this attack, rough deposits will result. Cyanide type baths do not readily attack magnesium and can be used without modification.

Final Plating

Nickel Plating

Nickel may be applied from any of the conventional baths after copper plating. It is preferable that the nickel bath have a pH of about 4.0 or above, but good results have been obtained in lower pH baths. A copper plate of about 0.0005" minimum thickness, particularly on complicated parts must first be applied to prevent attack of the magnesium through the pores in the copper.

Cadmium and Zinc Plating

Cadmium and zinc have been applied directly over the zinc immersion coating from standard cyanide baths. Application over the initial copper strike has produced better results than application directly over the zinc immersion coating.

Brass Plating

Brass may be applied either directly to the zinc immersion deposit from a standard cyanide type bath or after the initial copper strike.

Silver Plating

Silver may be applied from conventional cyanide baths after the initial copper strike, but it is preferable to plate heavier copper and apply a nickel strike, before silver plating to obtain the best adhesion to the copper itself.

Chromium Plating

Chromium has been applied directly to the zinc immersion coating in standard baths. The adhesion of the chromium has not yet been satisfactory when applied in this manner. Copper-nickel-chromium deposits may be readily applied.

Racks

Conventional non-magnesium racks may be used in this process. Organic rack coatings must be used to confine the exposed rack area to a minimum for

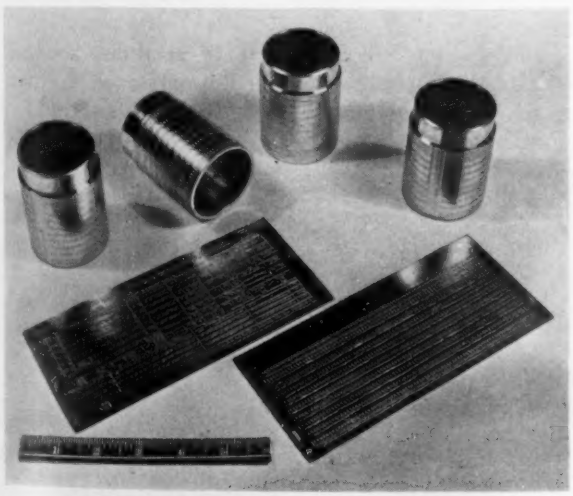


Figure III—Chrome plated magnesium printing plates and cylinders.

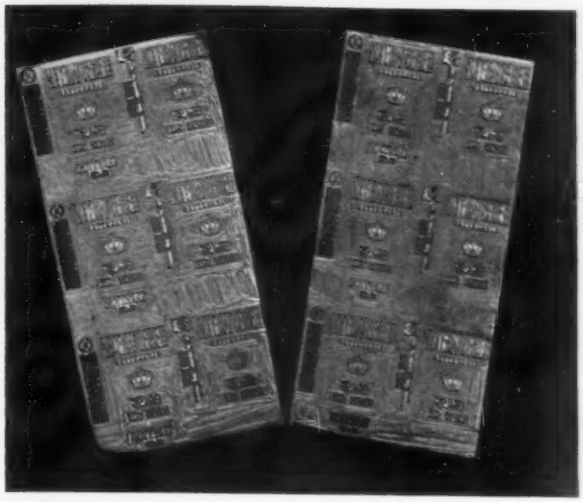


Figure IV—Direct printing plates of magnesium alloy chrome plated for wear resistance.

electrical contact with the magnesium. The racks must be given a copper strike coating on exposed areas before use and then used only for copper plating or given a copper strike after each cycle when used in electroplating metals other than zinc or cadmium. It has been observed, when magnesium is in contact with other metals, an electrolytic effect occurs that interferes with a proper zinc coating being formed adjacent to the rack contact points in the zinc immersion bath. Copper also takes the zinc coating in this bath immediately when in electrical contact with magnesium and this cell action is averted. Racks made of magnesium alloys may be used, but give poor electrical contact for the high current densities involved in chromium plating.

Stripping of Deposits

In stripping deposits from magnesium, some care must be taken to avoid severe etching of the surface. Copper may be stripped using the alkaline polysulphide dip followed by a dip in cyanide. To remove nickel the work is made the anode in an aqueous bath containing 15-25% hydrofluoric acid and 2% sodium nitrate. In this bath, the nickel goes into solution over a wide range of current densities. Upon being exposed, the magnesium surface polarizes completely due to the formation of magnesium fluoride.

Chromium may be removed by the standard practice for steel or nickel. The work is made the anode in a hot alkaline carbonate or hydroxide solution.

Corrosion Resistance

Chromium plated parts, such as handles for file cabinets, etc., have been exposed in a laboratory atmosphere for one year with no indication of corrosion or blistering of the plating. In some cases, these parts were plated with 0.0005" of nickel. In fact there has been no particular indication of corrosion of the magnesium or blistering of the plate during exposure of samples indoors, irrespective of the type of plating applied, for periods of six months to one year.

Silver and chromium plated test panels have with-

(*Concluded on page* 100)

Throwing Power of Electroplating Solutions

By A. Mankowich, *Darlington, Maryland*

Introduction

A GOOD many years ago[1] the statement was made that it was desirable to determine periodically whether or not the use of a term such as "throwing power" had served a useful purpose. It is the object of this paper to review the various definitions of throwing power that have been proposed. Reference to the term today implies usually its definition by *Haring and Blum*[2] and its determination by the Haring Cell[3]. Little mention is made of the considerable work of other investigators, possibly because of the superiority of the Haring and Blum concept, despite its admitted limitations. This review will indicate some of the reasons for the continued popularity of the latter, as well as the reasons for the criticism directed against it.

Haring and Blum Definition

Although the studies of throwing power by *Haring and Blum*[2] and by *Haring*[4] were not the first to appear in the literature, they will be discussed first because they provide an excellent background to which the work of other investigators may be compared. The few earlier investigations[5,6] will be touched on later.

An electroplating solution is considered to have good throwing power if it can plate the recessed portions of an object without the aid of auxiliary or conforming anodes. The chief characteristic of such a solution is uniformity of metal deposition over the area plated.

The Haring Cell is a device to quantitatively measure a very simple case of throwing power, Figure I. The cell is usually made of hard rubber (Pyrex glass and glass-lined steel boxes have also been used), slotted at the ends and also at the sides 2.5, 5.0 and 10.0 centimeters from one end. The inside dimentions are: length, exclusive of slots at ends, 15 cm; width, 5 cm; and depth below the solution level, 5 cm. Sheet metal cathodes are placed in the slotted ends of the Cell, and are connected by a metal rod. A perforated or gauze electrode is used as the anode, being placed in one of the sets of slots between the ends of the Cell. Such an arrangement tends to make the current density on each cathode uniform. Now, if the far cathode is twice as far from the anode as the near cathode, the solution resistance from the far cathode to the anode is twice that from the near cathode to the anode. Thus, if

R_f = solution resistance from far cathode to anode.
R_n = " " " near " " "
D_f = Distance from far cathode to anode.
D_n = " " near " " "

Then,

$$\frac{R_f}{R_n} = \frac{D_f}{D_n}$$

Now let $\frac{D_f}{D_n} = K$

If we assume that a high frequency alternating current flows in the cell, there is no polarization at the cathodes. It will also follow that, if

I_f = current density on far cathode
I_n = " " " near "

Then,

$$\frac{I_n}{I_f} = \frac{R_f}{R_n} = \frac{D_f}{D_n} = K$$

By definition, the ratio $I_n : I_f$ is called the "primary current distribution" ratio, and is numerically equal to the distance ratio, K. Now, let us assume that a

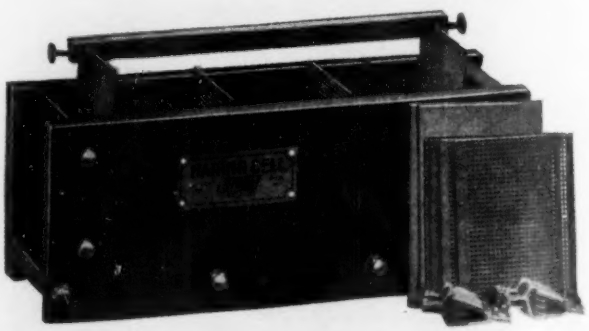


Figure I—The Haring Cell, showing gauze anodes in two of the three possible positions. The other position is in the slots halfway between the right hand gauze anode and the cathode.

direct current flows in the cell for a certain time. Each cathode will gain in weight. By definition again, the ratio of the gain in weight of the near cathode to that of the far cathode is called the "metal distribution" ratio. Thus, if

m_n = Weight of metal deposited on near cathode
m_f = " " " " " far "

Then,

$$\frac{m_n}{m_f} = M = \text{Metal Distribution Ratio}$$

Haring and Blum then proposed the following definition of "throwing power": "*the deviation (in percent) of the metal distribution ratio from the primary current distribution ratio*". Thus,

$$\textbf{Throwing Power} = 100 \times \frac{K - M}{K}$$

Now, since perfect throwing power implies a condition such that the metal distribution ratio is equal to 1, it is obvious that the value given by the Haring and Blum equation in such a case will be less than 100 per cent. Thus, for perfect throwing power,

$$100 \times \frac{K - M}{K} = 100 \times \frac{K - 1}{K}$$

In addition, it is evident that the throwing power numerical value will in all cases depend upon the distance ratio used in the determination. These rather minor disadvantages have given rise to several modifications of the Haring and Blum definition.

Pan-Heatly Modification

Pan[7] pointed out that it would be desirable for the equation for throwing power to give a numerical value of 100 per cent in all casess of perfect throwing power (when M = 1). *Heatly*[8] had attempted to accomplish this by comparing the Harine and Blum value with the value calculated for perfect throwing power for the same distance ratio, K. This modification was called "throwing efficiency" by Pan.[7] It is derived as follows:

a) Actual throwing power $= 100 \times \dfrac{K - M}{K}$

b) Perfect throwing power $= 100 \times \dfrac{K - 1}{K}$

$$\therefore \text{Throwing Efficiency} = \frac{\text{Actual throwing power}}{\text{Perfect throwing power, or}}$$

$$100 \times \frac{\frac{K - M}{K}}{\frac{K - 1}{K}} = 100 \times \frac{K - M}{K - 1}$$

But, although the numerical value of "throwing efficiency" does indicate how closely the throwing power has approached the ideal, and in addition is 100 per cent when M = 1, it still is not independent of the *distance ratio, K.*

Field Modification

Field then proposed a formula[9] for throwing power, also based on Haring Cell data, which gives numerical values that vary very little with change in the distance ratio. Also the numerical value of throwing power is 100 per cent when the metal distribution ratio is 1. In addition all values lie between +100 per cent and —100 per cent, thus eliminating the extremely large negative throwing power values possible with the preceding definitions. The formula suggested by Field is as follows:

$$\text{Throwing Power} = 100 \times \frac{K - M}{K + M - 2}$$

Harr Modification

Harr retained the definition of Haring and Blum and the Haring Cell. His contribution[10] consisted of substituting wire cathodes for the sheet metal cathodes of the Cell. Using a cell whose inside dimensions were 50 cm. long by 6 cm. wide by 7 cm. deep, Harr fashioned his cathodes from 0.025 inch copper wire, bending the wire to form 5 passes, each 2½ inches long and 3/16 inches apart. The wire cathodes were placed at the ends of the cell. The reasons for this substitution were said to be the unequal heating effects in the cell compartments due to the difference in the currents flowing therein, which caused changes in solution conductivity and cathode polarization and

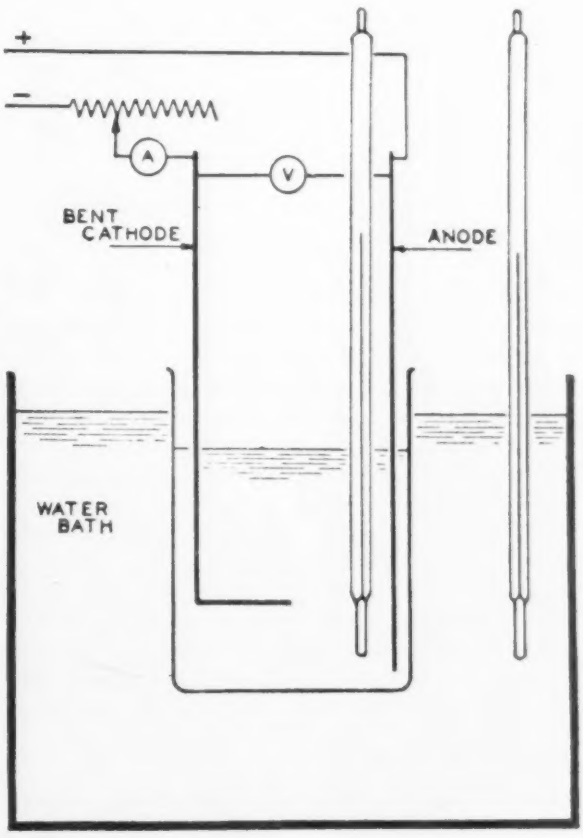


Figure 11—Schematic illustration of the Bent Cathode test for throwing power.

thus led to erratic results when sheet metal cathodes were used, especially at higher current densities. With wire cathodes, more reproducible values were obtained because the total current flowing in the cell was so small that the difference in heating effects due to current distribution was not appreciable.

Rogers and Conlon Modification

In this modification,[11] two brass plates wired back to back serve as the cathode. This cathode is placed between two anodes at an arbitrary distance ratio of 3 : 8. The two brass plates (compound cathode) are weighed before and after plating.

Then,

$$\text{Throwing Power} = 100 \times \frac{\text{Weight of Deposit facing Far Anode}}{\text{Weight of Deposit facing Near Anode}}$$

Braund Modification

Braund[12] first called attention to the phenomenon discussed under the Harr modification; namely, that the unequal heating effects in the Haring Cell compartments will affect the primary current distribution, K. He suggested a correction factor to take into account the increased conductivity of the compartment of the near cathode. Thus, if

C_n = specific conductivity of solution at temperature of near compartment.

C_f = specific conductivity of solution at temperature of far compartment.

K = primary current distribution ratio.

Then,

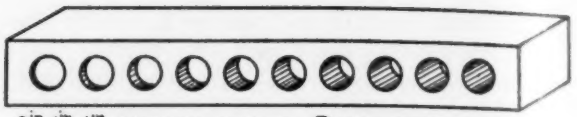
$$K^1 = \frac{C_n}{C_f} \times K = \text{corrected primary current ratio.}$$

This value K^1 is then used for K in the regular Haring and Blum formula.

Limitations of the Haring and Blum Definition

Most of the preceding modifications were proposed in order to correct obvious minor disadvantages in the original Haring and Blum definition of throwing power. The admitted limitations of this definition should be noted, however, before mentioning some of the remaining criticisms. Haring and Blum stated[2] that a value for throwing power has no significance unless the value of K and of the current density upon at least one of the two cathodes are also specified. A manufacturer of the Haring Cell[3] pointed out that throwing power results are comparable only when the same sized cell, the same cell ratio, same solution temperature and same total current are used. *Farber and Blum* emphasized again[13] that the value of throwing power depends upon the size of the cell and the primary ratio used.

In the writer's opinion, the most serious criticism of the Haring and Blum concept of throwing power was that made by *Heatly*,[8] who indicated that the ratio of solution resistances to two adjacent parts of a cathode was not constant, and that the currents to



8in x 1in x 1in BRASS OR STEEL BAR DRILLED HOLES RANGE IN DEPTH FROM 0.05in TO 0.5in BY 0.05in STEPS.

PAN'S CAVITY SCALE.

Fig. III—Pan's Cavity Scale.

the two parts exert an effect on each other, thus causing a readjustment in the current distribution. Since the Haring Cell does not simulate such actual practice, some doubt was raised as to the practical value of its data. Haring answered this criticism[4] with the statement that this factor was not fundamental and that results from the Haring Cell parallel those in actual practice. Haring and Blum have claimed that throwing power depends upon three factors, (a) change in cathode polarization with current density; (b) conductivity of the solution; and (c) change in cathode efficiency with current density.

Other Modifications

One of the few studies antedating Haring and Blum was that of *Horsch and Fuwa*[5] on the throwing power of cyanide zinc plating solutions. They arranged three plates, each connected to the cathode, at varying distances from the anode. The weight of metal deposited upon each plate was determined, thus giving an indication of the metal distribution in the solution. In this conception of throwing power, each of the three plates exerts an effect on the other two, thus simulating somewhat the condition that obtains in commercial plating. However, the criticisms of this method are that (a) the primary current distribution cannot be determined, and (b) the current density on each plate is not uniform.

Another investigation made prior to the work of Haring and Blum was that of *Arndt and Clemens*.[6] They studied the throwing power of nickel plating solutions by means of a cathode consisting of two plates, one of which contained a small opening through which the current passed to reach the other plate. The same criticisms apply to this method as to that of Horsch and Fuwa.

The Schlötter-Korpiun Equations

These investigators (14) proposed three equations for the calculation of throwing power values of a plating solution. First, if

I_1 = maximum current density consistent with good quality plating.

I_2 = minimum current density necessary to produce a satisfactory deposit.

C = specific conductivity of the solution.

e_1 = cathode polarization at current density I_1

e_2 = " " " " " I_2

Then,

$$\text{Throwing Power} = \frac{I_1}{I_2}\left[1 + \frac{C}{I_1}(e_1 - e_2)\right]$$

Since the above equation is based on the ratio of

maximum and minimum current densities, it tends to define "covering power" more than throwing power. While these two terms are more or less parallel in their effects, throwing power implies ability to deposit uniformly into recesses of a cathode, while covering power defines the degree of deposition over the surface of a cathode. However, as will be shown subsequently, the terms have been used interchangeably.

In the second empirical equation,

I_1 = maximum current density consistent with good quality plating.

I_2 = greater than the minimum current density necessary for a good deposit, and such that $\frac{I_1}{I_2} = 5$, or 10.

Q_1 = cathode current efficiency at I_1

Q_2 = " " " " I_2

Then,

$$\text{Throwing Power} = \frac{I_1 \times Q_1}{I_2 \times Q_2}\left[\frac{I}{\frac{C}{I_1} - (e - e_1)}\right]$$

In this equation, the investigators have followed the example of Haring and Blum by defining their value for throwing power in terms of an arbitrary current ratio depending on a distance ratio to some extent.

In their third equation, Schlötter and Korpiun simplified their first equation by several assumptions, and arrived at the following:

$$\text{Throwing Power} = \frac{1}{\frac{c}{I, e^1}}$$

Covering Power—Bent Cathode Method

Farber and Blum defined[13] covering power as the ability to completely cover a cathode with deposited metal, or the extent that a cathode is covered. Throwing power, as already noted, implies uniformity of deposition on all parts of a cathode. One of the minor disadvantages of the Haring and Blum determination from the standpoint of the practical plater, is that the required equipment is rather complicated. To meet this objection, several investigators used cathodes bent at right angles ("bent cathode" method) to measure covering power or to qualitatively measure throwing power[15, 16, 17]. In this method, a flat anode is placed opposite the bent cathode (90 degree bend), which thus includes recessed and protruding portions. Figure II. Farber and Blum[13] modified the method slightly, making the determination in the Haring Cell, using a definite distance ratio, and measuring the area covered by the deposit. Their results indicated that while the bent cathode method parallels the results of the Haring and Blum determination, it is not sensitive enough to distinguish between small differences in throwing power. Of course, a secondary advantage of the bent cathode method is that it may be used as a control tool for keeping a plating solution at optimum operating condition.

Figure IV—Hosdowitch modification of Pan's Cavity Scale.

Piersol[18] proposed the use of a 4 inch by 4 inch sheet of copper, in the center of which was stamped a ½ inch wide groove varying from zero depth at one end to a ½ inch depth at the other. This sheet when used as a cathode gives semi-quantitative results of throwing power, as estimated from the maximum depth at which satisfactory deposition is obtained.

Pan, who had critically analyzed[7] the throwing power definition of Haring and Blum, proposed a new definition[19] somewhat related to covering power; namely, throwing power is the ability of a solution to deposit in recessed portions of a cathode without "burning" the protruding portions. He measured throwing power by a cavity scale, which was a bar of metal containing a series of holes of the same diameter but varying depth, see Figure III. The holes were numbered so that each expressed the depth as percentage of the diameter. Throwing power was thus the number on the deepest hole completely and satisfactorily plated, while no part of the cavity scale was burned from too high a current density. Thus, if:

d = depth of deepest cavity completely and satisfactorily plated, with no burning of any part of the cavity scale.

D = diameter of cavity

Then,

$$\text{Throwing Power} = 100 \times \frac{d}{D}$$

Pan claimed that results from the cavity scale more closely parallel commercial practice than did those from the Haring Cell, especially in the case of chromium plating solutions.

As described above, the cavity scale suffered from two disadvantages. First, it was too large and bulky, and second, it was extremely difficult to produce a uniform current density on the scale even when using a plating fixture designed for the purpose. *Hosdowich* proposed[20] a modification of the bar scale, consisting of a disc with the cavities arranged in a circle on one

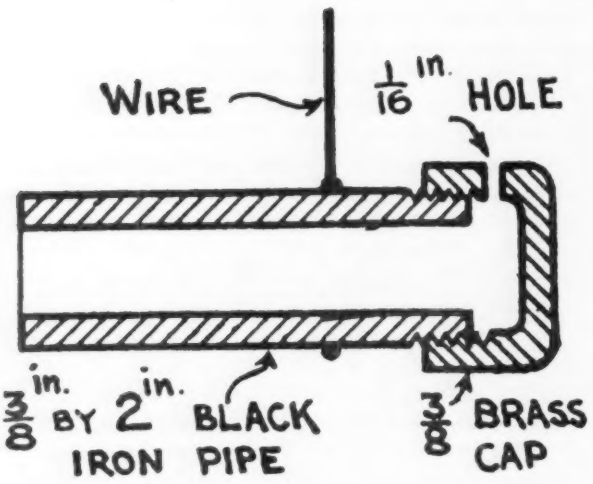


Figure V—Tubular cavity scale for throwing power devised by Pan.

face, Figure IV. Such a scale (disc-type), measuring only 6.77 cm. in diameter, eliminated the faults of the original bar scale, and could be used either in a commercial tank or in a small experimental arrangement. It is to be noted that while Pan's original cavity scale definition implied the use of the highest current density consistent with no burning of any portion of the scale, he later considered it proper to use the method with any suitable current density.

The 100 per cent cavity on the disc-type scale measured usually 10 mm. deep by 10 mm. in diameter. Plating solutions of high throwing power easily covered such a cavity. Rather than deepen the cavities, Pan devised a tubular modification[21] of the disc cavity scale, see Figure V. Originally this consisted of a piece of standard 3/8 inch iron pipe, 2 inches long, threaded at both ends, and closed at one end by a brass cap which contained a 1/16 inch hole. Throwing power was evaluated as formerly, the depth of plating on the inside of the pipe expressed as percentage of the diameter of the pipe. In making a determination of throwing power with this method, the open end of the tube faced the anode.

Wright[22] described a device along the same lines as the preceding tubular scale.

Pan later improved his tubular scale[23] by constructing it out of a solid rod which was cut into halves before the cavity was drilled. The cavity was made 60 mm. deep by 10 mm. in diameter. When ready for a determination of throwing power, the two halves of the scale were held together by three screws. The advantage of this improvement was the ease with which the depth of the deposit could be measured on the inside of the scale after a test. A limitation of the tubular scale is that, because of excessive hydrogen evolution due to low current efficiencies, it is unsuitable for use with chromium plating solutions.

Mathematical Conceptions of Throwing Power

No discussion of throwing power would be complete without a reference at least to the excellent mathematical presentations of throwing power that have appeared in the literature. Although of limited practical and experimental value, they are of interest from a scientific standpoint. *Piersol's* papers on the "coefficient of metal distribution" and "electrostatic distribution"[24] and *Kasper's* papers on current distribution[25] will be of interest to those familiar with related expressions described in simpler fashion by Haring and Blum.

Remarks

In conclusion, it appears to the writer that the continuing popularity of the Haring and Blum definition of throwing power and its determination by the Haring Cell is due to its relative ease of determination and its dependence on factors shown to influence throwing power. None of its limitations and disadvantages appear to be serious enough to warrant its discontinuance in studies of the properties of plating solutions. More consideration should be given to Field's modified equation for throwing power[9].

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Fluid Mechanics: Forgotten Factor in Electroplating—Part III

Joseph B. Kushner, *Metal Finishing Consultant, New York City*

This is the third in this series of timely discussions on the importance of various physical factors affecting electrodeposition of metals, and points out how viscosity affects dragout, concentrations, and electropolishing.—ED.

IN PART II of this series of articles, surface tension, a property of all fluids, and its vital relationship to electroplating, was discussed. We will now consider an internal property of fluids that is as equally important, if not more so, in connection with electroplating. This internal property is called *viscosity*. The name is derived from the Latin word *viscosus*, meaning "sticky."

Viscosity can be simply explained as the resistance offered by a layer of fluid to another layer of the same fluid moving across it. It is sometimes called the internal friction of a fluid.

Perhaps the easiest way to make it clear is through an analogy often used, that of a deck of cards. If you had a perfectly smooth deck of cards and you slid the top card along the deck, the card beneath it would not move, nor would any other card beneath that. On the other hand, with any actual deck of cards, you cannot slide the top card along without moving the card underneath to some extent and the one below that and so on, as is illustrated in Figure I. The friction between the card surfaces causes the force that is applied to the top card to be transmitted to the next card and so on down the deck. In other words, the resistance the card moving force encounters is of such a nature to oppose *shear*. When one of the cards starts moving in one direction, the rest of the deck wants to go in the same direction. In the case of a liquid, which can be imagined to be divided into an infinite number of planes or layers, when you slide one layer over another this shearing force is resisted by the friction force of viscosity. Where one layer of the liquid goes, the rest wants to go also!

Viscosity is mathematically defined in the following way:

The Author

If there are two planes of liquid, each of area A, separated by a distance L, and a force F is applied to the top layer, as shown in Figure II, causing it to move with a velocity U with respect to the bottom layer, then it is found by actual experiment that the force F required to produce this motion varies directly with the velocity U and the area A, and inversely with the distance L between the two layers. Stating this variation in symbols gives

$$F \propto \frac{AU}{L}.$$

To make this an algebraic equality, a proportionality constant Z must be inserted on the right hand side, giving

$$F = \frac{ZAU}{L}.$$

If F is measured when the area A equals 1 sq. cm., U is 1 cm. per second, and L is 1 cm., then F = Z; and accordingly, Z is the force in dynes required to produce a relative motion of one cm. per second between two liquid planes one sq. cm. in area, one cm. apart. Z, the proportionality constant, defined

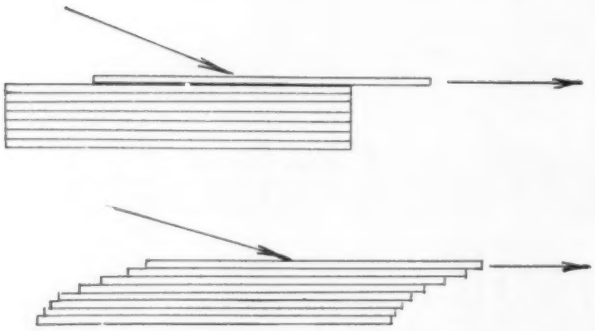

Figure I. Illustrating effect of friction. Upper sketch—no friction present. Lower sketch—friction present.

this way, is called the viscosity of the fluid under sideration.

The name of the unit of viscosity is the *Poise*, after the French physicist, Poisuelle, who carried on many fundamental investigations in the field of viscosity. Practically speaking, the Poise is too large a unit for convenience in use (the viscosity of water at room temperature is approximately .01 Poise) so the units actually used are *centipoises*, which are hundredths of a poise. Thus the viscosity of water at room temperature is given as 1 centipoise.

Viscosity is extremely important in electroplating because the resistance offered to any body moving through a fluid is a function of the viscosity of the fluid. In electroplating, the ions moving through the electrolyte, encounter such frictional resistance. Viscosity is also a governing factor in determining the turbulence of agitation, such as may be produced in a plating bath, the thickness of liquid film clinging to a piece of work removed from the plating bath (drag-out) and the thickness of the diffusion film at the cathode and anode during the electroplating process.

Viscosity is a complex function of composition, concentration and temperature. In general, viscosity decreases with temperature rise and increases with increasing concentration. In water for example, there is very roughly a 2% reduction in viscosity with every one degree of temperature rise (centigrade) but actually, for most liquids, the viscosity is an exponential function of the temperature. In a sugar solution at room temperature, changing the sugar concentration from 20% by weight to 40% increases the initial viscosity 300% and changing the sugar concentration by weight to 60% increases the initial viscosity 2800%! Viscosity is also a function of chemical composition or structure because certain substances possess the power of acting as "internal lubricants," so to speak.

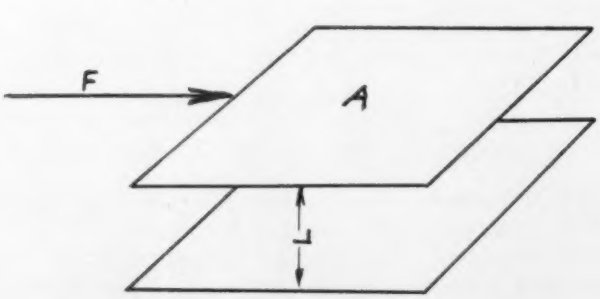

Figure II. Viscosity definition.

There are many ways in which viscosity may be measured but the use of the Ostwald pipette, in which the viscosity is determined by the time required for a liquid to fall through a given distance in a capillary tube, is probably simplest and most convenient for electroplating control use.

Viscosity and Drag-Out

In removing an object from a plating bath a certain amount of the electrolyte clings to the surface of

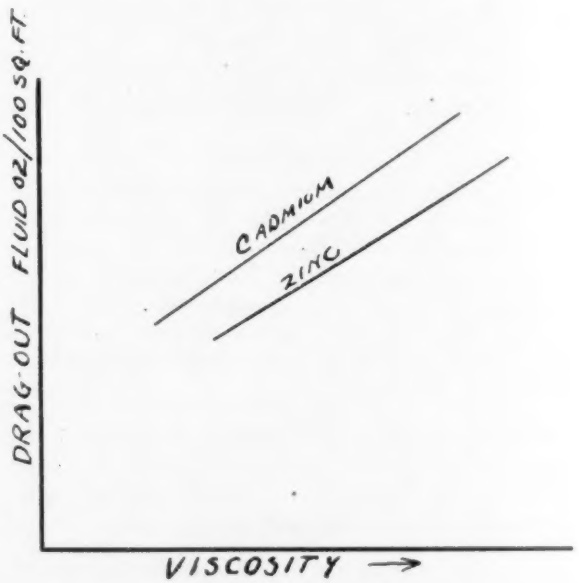

Figure III. Dragout vs. viscosity (cyanide baths).

the object because of the surface attractive forces of adhesion (surface tension) and the frictional forces between the liquid and the solid. In order for the liquid to have come away from the main body of the bath, it must have been *sheared* away. Obviously, then, the viscosity of the plating bath must play a very important role in determining the thickness of the clinging layer (amount of drag-out).

To the writer's knowledge few studies have been made of the subject. Experimenters in another field have shown that in the case of wires being removed from a liquid, the thickness of the liquid layer clinging to the wire varied directly with viscosity, but theoretical considerations show that the variation is not necessarily linear in all cases, the form of the function depending on shape of the object as well.

Hull, in a study presented at the A.E.S. convention of 1938, gave some data on the effect of viscosity on drag-out. He found that there was a direct variation (under essentially constant removal methods) between

the viscosity of the plating baths tested and the volume of drag-out on a metal panel. (See Figure III). In fact, the correlation was proposed by Hull as a method for actually determining drag-out losses from plating solutions, based on the viscosity of the plating solution and the square feet of area passing through the tank. Actually this is open to question, inasmuch as changing the withdrawal velocity or the shape or angle of withdrawal will cause a marked difference in drag-out losses, as was proven by *Soderberg* in his paper on drag-out presented to the 1935 A.E.S. Convention. Furthermore, surface tension in all probability will also effect the result.

In considering two plating solutions, however, the relative drag-out losses can be determined between the two, all other things being equal, by a simple viscosity measurement. Thus if a cyanide copper solution which has a viscosity of 1 centipoise is being compared with respect to possible drag-out loss with another copper solution which has a viscosity of 2 centipoises, the 1 centipoise solution would have half the drag-out loss (by *volume*) of the 2 centipoise

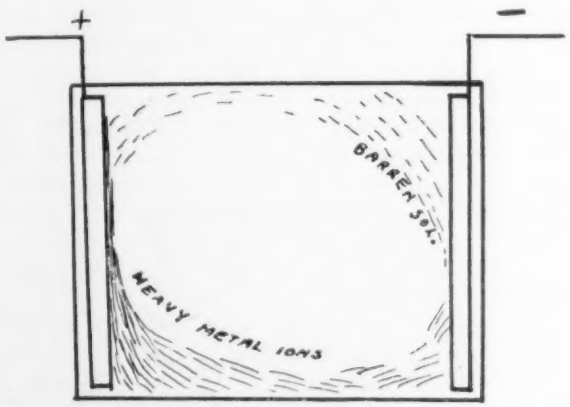

Figure IV. Natural convection during electroplating.

solution. Actually, the saving in terms of weight of metal lost would be considerably more than 2 to 1 in favor of the low viscosity solution because the low viscosity solution has a lower copper concentration as well as a lower viscosity.

In order to minimize drag-out losses, Hull suggests as values which should not be exceeded for the common cyanide plating baths, the following viscosities:

CYANIDE TYPE BATH	VISCOSITY (cp)
Cadmium	1.5
Copper	1.4
Silver	1.2
Zinc	1.8

To reduce drag-out losses from a plating bath, the solution should be worked as warm as possible and it should have the lowest possible solids concentration, compatible with good results. A third possibility is to find an addition agent that will act as an "internal lubricant." There is room for a considerable amount of research on the subject of plating bath viscosity and drag-out!

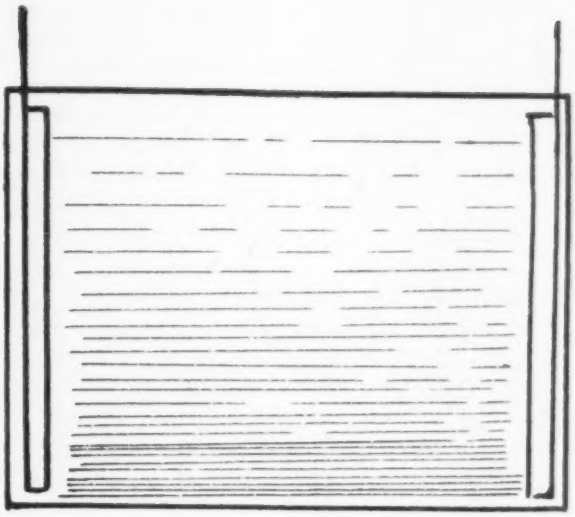

Figure V. Stratification in a plating bath.

Viscosity and Plating Bath Stratification

In the operation of a plating bath, as shown in Figure IV, the heavy metal ions, as they come off the anode, tend to sink because of gravitational forces. At the cathode where the heavy metal ions have just been deposited, the surrounding solution becomes lighter in weight and tends to rise. This causes a natural convection circuit as indicated in the figure.

The more viscous a plating solution is the less chance there is for natural mixing by convection because convection involves the motion of one part of a fluid with respect to another. This being so, as the process continues, (if not countered by some form of agitation) more concentrated solution tends to sink down to the bottom and remain there, while the lighter and less concentrated solution remains on top. The situation becomes similar to that in a poorly heated room in which all the warm air is near the ceiling and the cold air is near the floor. The solution, in other words, tends to stratify in layers (Fig. V) with the most highly concentrated solution at the bottom. Once such stratification has taken place, a plating solution may stand around for days, with extremely large concentration differences at the bottom and top of the tank.

Thus, for example, in data presented anonymously

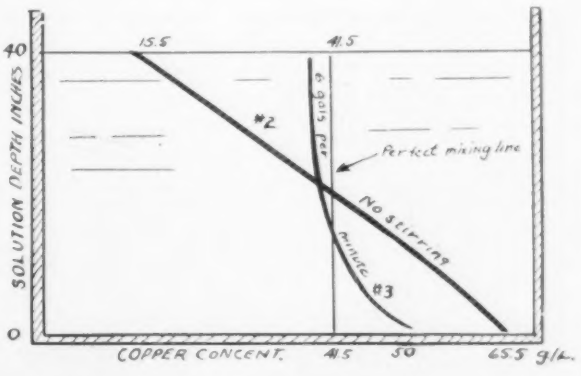

Figure VI. Stratification effect in a copper refining bath.

in *The Monthly Review* of the AES, a plater gives the following figures on stratification in a white nickel bath (mechanical plating).

SOLUTION IDLE 48 HOURS

	Sp. Gr.	Nickel (oz./gal.)	pH (colorimetric)
Top of tank	1.050	1.55	6.8
Center of tank	1.130	6.37	5.3
Bottom of tank	1.140	6.91	4.4

Here is a case where there is a variation of almost 90% in metal content, and 50% in pH! The figures are in all likelihood approximate, but they do give an idea of the possible magnitude of stratification.

Another study of stratification, this time made in a copper refining bath, which is essentially an acid copper plating solution, was made by *Pyne* many years ago. Operating at a current density of 36 amperes per sq. ft. he obtained the figures given below and in the graph (Figure VI), without agitation.

Depth Below Solution Level	*Copper Content grams/liter*	*Sulfuric Acid Content grams/liter*	*Sp. Gr.*
6″	23.4	179	1.185
17″	38.0	164	1.210
28″	51.8	151	1.230
39″	65.5	138	1.255

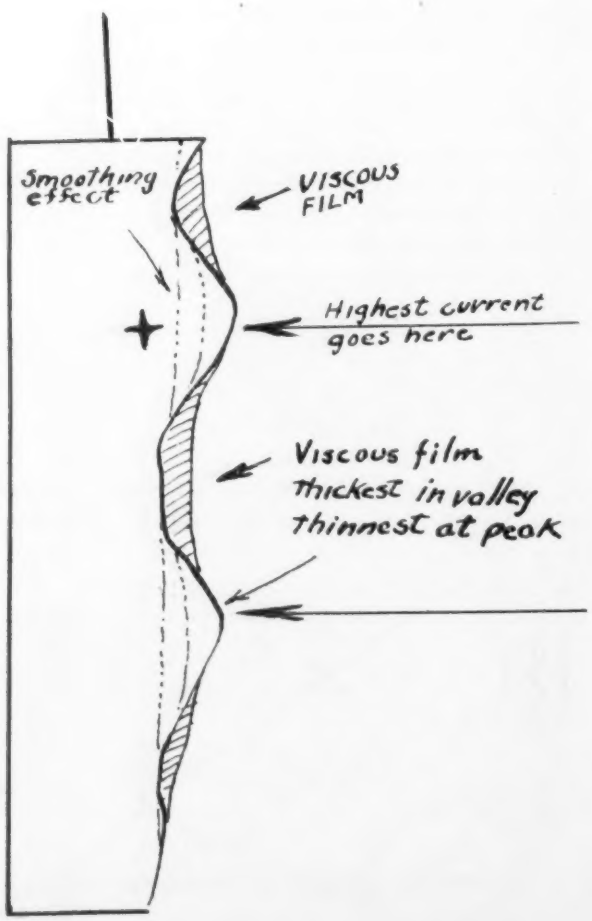

Figure VII. Electropolishing (magnified cross-section).

Here there is a concentration difference of 65% in metal from bottom to top, and 30% in acid content.

On circulating the solution through the plating tank at a rate of 6 gallons per minute, the following set of figures was obtained:

Depth Below Solution Level	*Copper Content grams/liter*	*Sulfuric Acid Content grams/liter*	*Sp. Gr.*
6″	38.4	174	1.213
17″	39.2	172	1.216
28″	40.2	171	1.216
39″	49.9	153	1.228

As shown by the graph, perfect mixing would have resulted in the vertical straight line showing an average concentration of copper of 41.5 grams per liter. With no agitation, curve ♯2 results and with a circulation of 6 gallons per minute curve ♯3 shows an approach to the theoretical line of perfect mixing.

Besides concentration stratification in viscous plating solutions there is also a possibility of thermal stratification if the bath is heated. In a bath that is heated from the bottom it is frequently possible to have a variation in temperature, particularly in deep tanks, of as much as 10°C. and more. Since many plating solutions show a rise of roughly 2% in conductivity with every 1 degree of temperature rise (As noted previously, viscosity diminishes by 2% with every degree rise permitting faster passage of the ions and therefore higher conductivity in the same ratio!), it is possible to have a variation in conductivity from this source alone of as much as 20%.

Every plater is familiar with the sight of plated deposits in which the plate is heavy on the bottom and light or burnt on top, and other types of non-uniformity along the vertical axis of the work. Aside from electrical considerations which tell us that larger amounts of current flow to the edges and points on a piece of work, the bogies of concentration and thermal stratification can be blamed for the rest!

To overcome non-uniform plating resulting from stratification, therefore, it is important that the plating solution have a minimum viscosity and that there be some means for properly agitating the plating solution.

Viscosity and Electropolishing

In electropolishing, viscosity plays an extremely important part. Electropolishing is an anodic process in which a metal anode is electrochemically attacked, in a suitable medium, in such a preferential manner that the rough spots (relatively speaking) are "smoothed" and a lustrous, if not mirror bright finish is produced. The theory that best seems to account for this action suggests that at the high current densities used, a viscous film of anode reaction products of relatively high electrical resistance, surrounds the work and settles in the "valleys" of the anode, leaving the "peaks" or high spots comparatively free of this product. Accordingly, the electrochemical action takes place preferentially at these peaks, which results in a gradual smoothing down of the surface to a lustrous state. This is illustrated in Figure VII.

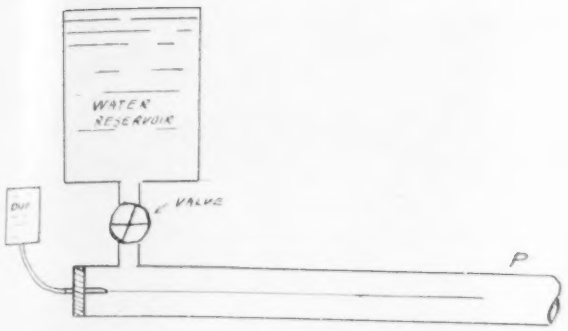

Figure VIII. Reynolds experiment.

If this theory holds, then control of the viscosity of the anode surface film is of vital importance, for the viscosity of this film controls the rate of flow or movement of the film and therefore the protection the film offers to low spots. Examination of the patent literature on electropolishing shows the presence in electropolishing electrolytes, very frequently, of viscosity increasing substances such as glycerine. With horizontal surfaces the viscosity, obviously would not be as important as with vertical surfaces, because on horizontal surfaces, a film once formed would tend to stay (on the top side at least), whereas on vertical surfaces a film of heavy anodic reaction products would tend to drop off because of gravitational effects, and this could only be countered by the resisting force of viscosity. Here is another excellent field for research!

Fluids in Motion

Many years ago a British scientist by the name of *Osborne Reynolds*, who was interested in the way water flowed in pipes, performed the simple experiment illustrated in Figure VIII. He had a reservoir outlet controlled by a valve which was used in filling the glass pipe P with water flowing at various rates of speed. At the inlet end, he had another smaller reservoir which fed into the main tube a needle thin jet of colored dye solution. Reynolds observed that when the water flowed below a certain rate of speed in the glass tube, the dye solution entering from the narrow jet did not mix with the rest of the water where it entered, but traveled downstream as a separate thread of color a considerable distance before it finally mixed or diffused into the main body of the stream. With the water stream velocity below this critical point, the dye entry jet could be shifted to any point of the pipe cross section and the same behaviour would be noted, i.e., straight line orderly flow parallel to the wall of the tube.

As the water stream velocity was increased by opening the feed valve more and more, a point was reached where the dye solution no longer traveled downstream with an orderly motion parallel to the length of the pipe. At this critical point, the dye solution, almost the instant it issued from the jet would be completely mixed with the water stream and the stream was uniformly colored throughout. This indicated that, above the critical velocity of water flow, a completely erratic and random motion took place in the water which was causing the immediate mixing of the dye solution and the water. Reynolds in this classic experiment discovered and recognized the two types of liquid flow, *viscous flow* and *turbulent flow*.

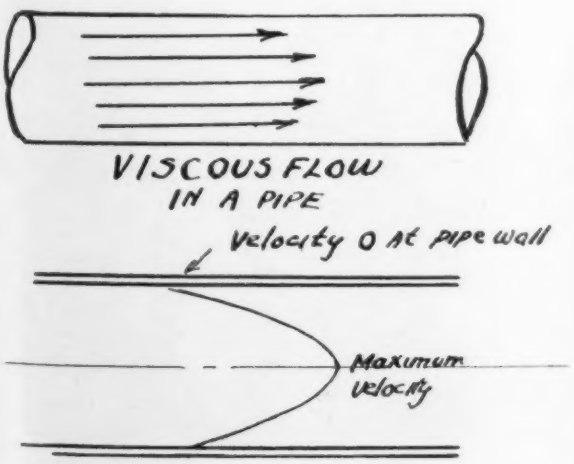

Figure IX.

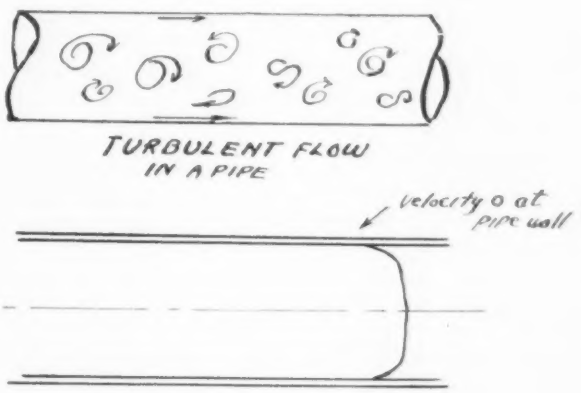

Figure X.

In viscous flow, such as in a pipe, the water particles move in straight lines parallel to the pipe walls and the velocity of flow is such that it distributes itself with respect to the pipe cross section, something as illustrated in Figure IX, in the form of a parabola. With turbulent flow, the motion is completely disorderly and there are eddies throughout the cross section except close to the pipe wall where the velocity falls off to zero. Repeated tests all prove that no matter how turbulent the flow, a region extremely close to the pipe wall is always in viscous flow. The viscous region or film may be reduced to practically the vanishing point, .001" or less, but it cannot be removed completely. In this viscous region, transfer of matter must depend purely on diffusion.

While this phenomenon was first observed in pipes, the same principle holds in any fluid-solid set up as long as there is relative motion between the solid and the fluid.

In honor of Reynolds, the criterion which determines whether fluid flow is viscous or turbulent, is called

(*Continued on page* 72)

Surface Finishing Automobile Moldings

By L. F. Strong, *Detroit, Mich.*

BECAUSE polishing and buffing is often one of the biggest single items in the cost of a finished metal product, a visit through Fisher-Ternstedt's main plant in Detroit, (Fisher Body-Ternstedt Division manufactures all interior and exterior door handles and hardware for all General Motors automobiles), provides an excellent lesson in controlling high polishing costs.

The firm's selection of wheels, glues, and abrasives, their methods of preparing the polishing and buffing wheels, and their actual polishing and buffing operations, are well laid out and as automatically efficient as possible. Although many types of moldings are processed in this plant, this article deals only with three types of automobile moldings: garnish, reveal, and outer panel.

In order to obtain a maximum uniformity in polishing wheel set-up, polishing wheel rooms were established. Wheels are made up of several sections of cloth buffs, each section consisting of from 25 to 30 layers of buff cloth which are sewed into one section. These sections of buff layers are glued together to form a wheel of desired thickness. Glueing has a tendency to make the wheel off-balance, and this is corrected on a wheel-balancing unit (Figure I), where the face of the wheel is made to run true with the shaft, with no "wobble." Wobbling of the wheel is corrected by the use of small lead weights which are attached to the sides of the wheels, and an arrow is painted on the side of the wheel to show the direction in which it should be rotated when put to use. Also painted on the side of the wheel is the number of the grade of emery used on the wheel. Each time a polishing wheel comes back to the wheelroom for setting up, it is coated with the same size of emery specified by the number on the side of the wheel.

The wheel is then given a sizing coat of melted glue, applied to the surface with a brush. This glue is kept at about 140° F. in water-jacketed electric heaters. After glueing, the wheel is rotated in an abrasive grain tray containing the desired grade of abrasive. At Fisher-Ternstedt these grades of emery vary anywhere from 40-300 grain size. The coarser grades of emery, (40-80), are used in preliminary operations for rough polishing when necessary. The parts are then worked down to a fine finish with the finer grades of emery, (150-200).

Polishing wheels may be given one, two or three coatings of emery; in any case the first two coats are allowed to set completely before the third or final coat is applied. The final coat is allowed to dry for 24 hours at room temperature before the wheel is used for production. To make the wheel flexible, at the start of the polishing operation the worker softens the cushion of the head by turning the wheel by hand, and hitting the head in several places with a round steel bar, at a 45° angle to the rotational plane of the wheel. This makes the wheel more pliable for polishing.

While polishing, the operator from time to time applies an emery cake and a grease stick to the wheel surface which gives an additional cutting action to the wheel. After polishing, the panels are sent to the plating department to be copper plated and copper buffed.

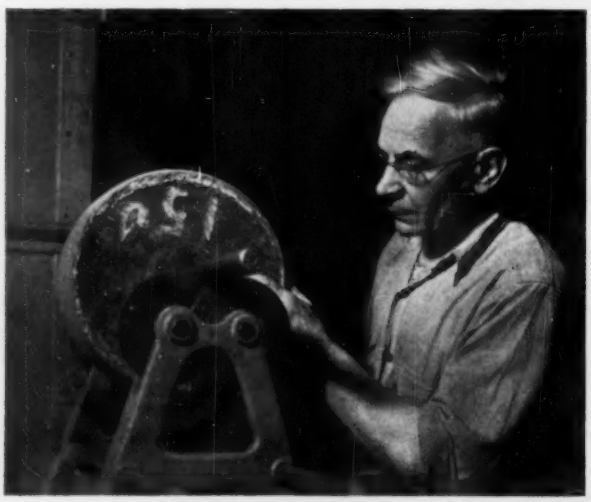

Fig. I—Balancing a polishing wheel—note lead weight and grit number on side of wheel.

Fig. II—Oscillating-type automatic buffing machine. Workman at far end loads parts into fixtures. Operator in foreground controls wheels and compound feeding.

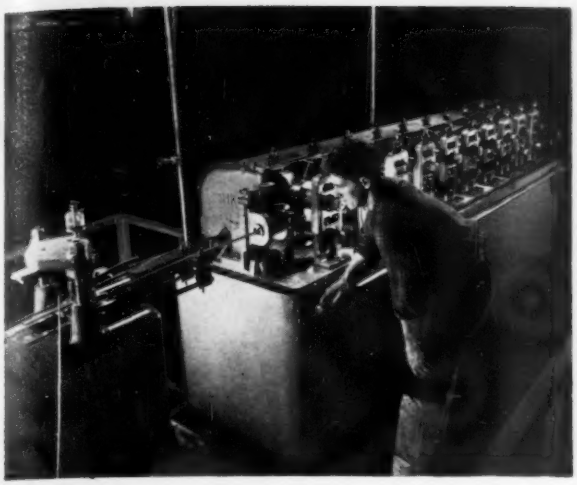

Fig. III—Rolling mill for forming edges on stainless steel trim molding.

Fig. IV—Automatic roller unit. Operator feeds abrasive to wheel thru foot-operated spray gun.

Copper buffing of these outer panels is done on an oscillating type machine. The machine is set up to accommodate two lengths of parts: left and right hand outer panels, and left and right hand rear quarter panels. This oscillating type machine, by the way, is adaptable, and is used for many other straight parts. Three panels are mounted on one fixture. A workman places the panels in the fixtures and starts them through the machine. The fixtures are carried thru the machine on a chain belt, as shown in Figure 2. Four buffing stations buff the topside of the panels, and two buff the sides of the panels as they travel past the wheels. Another workman stands beside the machine, controlling the wheels and application of the bar compound. This compound is a lime-based, copper or nickel coloring compound. This lime compound was developed at Ternstedt and is manufactured to their specifications. After this operation, these parts are cleaned, bright nickel and chrome plated, and are then ready for shipment to a General Motors car division.

Chrome-plated door garnish moldings, (inside window moldings), are buffed on an automatic roller type buffing machine. These moldings have already been polished at their welded corners, and have been copper and chrome-plated. Each molding is mounted on a buffing fixture and a special lime bar compound is applied to the wheels. The fixture is manipulated by a gear driven device which passes each molding under two wheels to complete the buffing. One wheel hits the top position and the other wheel hits the side. These roller type buffing machines also accommodate crease, or trim moldings.

With reveal door moldings (outside window moldings), the highly polished strip of 18% Chromium stainless steel passes thru a rolling mill shown in Figure 3, where the edges are formed and beaded and the strips cut off to length. Another light forming operation is performed on these parts, after which the inside edges are buffed, using a three-wheel operation on an automatic machine. The compound used for this operation is a stainless steel bar compound containing aluminum oxide abrasive. Further forming operations are then made, and the moldings arrive at an automatic roller buffing unit similar to the one shown in Figure 4. At this particular machine, however, a liquid tripoli compound is applied to the buffing wheels from a spray gun operated by a foot pedal. The liquid compound has proven very economical, as the compound is applied to the wheels only as needed, as compared to the continuous application and waste of bar compounds. Furthermore, there are no loose ends, or nubbins, to be reclaimed or wasted. Each molding is mounted in a buffing fixture and is oscillated under the wheel by the operator. Since the inner edges have already been buffed in the preceding stages, the top surface is hit the hardest so that it will blend into the inner edge.

The method of keeping the fixture under the buffing wheel in this machine is unique. On each fixture is mounted a section of roller chain. Under the buffing wheel, mounted on to the bench, is a sprocket that is rotated by a drive unit located under the bench. The operator merely has to engage the chain and the sprocket, and the molding is moved uniformly thru the buffing cycle. This roller unit is adaptable to many other types of parts, the only requirement being a jig designed for the particular part being buffed. At present 25 or 30 different forms are handled on this equipment. Figure 4 clearly shows the chain mounted on the under outside of the buffing fixture.

When the scarcity of buffs was prevalent, Ternstedt decided to manufacture their own. A department was set up which now supplies most of the buffs used throughout the plant. To control the hardness of the buffs, four types of stitching were standardized on; spiral sewed, square sewed, vertical stitched, and a utility buff on which the stitching is varied. The square sewed buff is the hardest and is used for copper buffing, while the spiral sewed buffs are used principally on interior hardware for final coloring operations.

By a careful study and unceasing supervision of their polishing and buffing methods, the company has managed to effect important economies in their finishing costs.

The Mechanism of Exfoliation of Electrodeposited Surfaces

By A. T. Steer, D.Sc., *Birmingham, England*

Introduction

THE phenomenon of exfoliation by partial or complete peeling of an electrodeposited layer, or the condition that produces "blisters" in a plated layer after storage, has been a problem to electroplaters for a long time. Its cause is commonly attributed to lack of chemical cleanliness during the preparation prior to actual plating, and doubtless this is one of the causes. This view, however, is offset by the enormous amount of research which has been carried out on the various modes of cleaning, and with modern anodic and cathodic cleaners it is difficult to account for lack of cleanliness. Yet exfoliation occurs just as ever, and the tragedy of this occurrence is that the usual adhesion and porosity tests give the plating a clean bill of health at the time of its deposition, but after storage or service the plate shows signs of this "loose-skin" effect, resulting in final exfoliation of the plate from the base metal. This "delayed action" type of exfoliation, occurring after a lapse of weeks or even months, cannot be associated with original grease, oil, or dirt left on the surface at the time of processing in the plating shop, and hence it becomes necessary to look further for an explanation. There is obviously only one line to pursue when investigating this problem, and that is to find out the properties of the surface of a metal and its influence on the electrodeposition. After all, the plater is only concerned with the surface, and so the reactions of surfaces to various treatments, both of a physical or a chemical nature, become a vital link in the chain of plating processes. The object of the present paper is to deal with this aspect of the problem only.

Nature of Polished Metal Surfaces

Our first knowledge of surfaces and their characteristic properties was due to G. T. Beilby's work, and from his observations he originated the well-known "amorphous layer theory." This theory postulates that when a crystalline body, such as a metal, is polished or burnished, the surface layers of the exposed crystalline formation are caused to flow. This flowed metal layer, according to the hypothesis, is no longer composed of orderly arranged crystals, as existed prior to the polishing, but is composed of randomly situated atoms. Metals are crystalline solids, at least as far as general experience and practice is concerned. Crystals are characterised by the orderly arrangement of their constituent atoms, and although geometrically perfect forms of crystals are not found in a metal as far as the appearance of their external form is concerned, X-ray crystal analysis shows that despite the disparity in shape between a fully formed crystal and the grains of a metal, the internal structure of both are similar. Each possesses characteristic symmetry, each is composed of unit cells of a definite order, such as cubic, hexagonal or tetragonal forms, and the behaviour of the perfect crystal is simulated by the grains of the massive metal.

The outstanding property of a metallic crystal is its capacity for "slipping" when subjected to a stress. This property is remarkable, in that the phenomonen of slip is a very restricted process, and after primary slip has taken place, the plane that has yielded to the imposed stress appears to reinforce itself so that a greater stress is required before further movement can take place. This property is as true of the surface crystals as it is of the internal crystals which compose the bulk of a metal. The action of polishing imposes a stress on the surfaces of the crystals lying in the plane of the metal surface. This causes slip to take place and with successive slipping the faces become deformed. Another characteristic property of metallic

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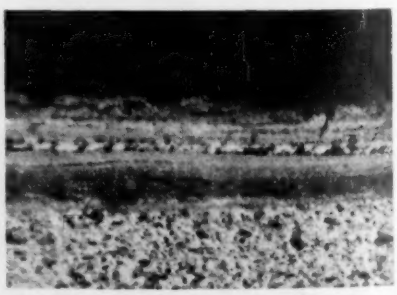


Fig. 1—(Left) Annealed medium carbon steel, turned and ground. Section through surface showing plastic deformation and severe fragmentation. Section cut from area from which plating exfoliated completely, due to surface condition. (1200 x)
Fig. 2—(Right) Section through flow-layer produced by tangential pressure of cam working on hard-chrome plated surface of oil hardened, medium carbon steel. Chrome thickness .008". Thickness of flow-layer .00027". Time to produce this condition was 5 hours. (3000 x)

Fig. 3. Surface distortion, fragmentation and bridging on 60 : 40 brass machined on an automatic. Dark phase = β brass, light phase = α brass (× 1,200).

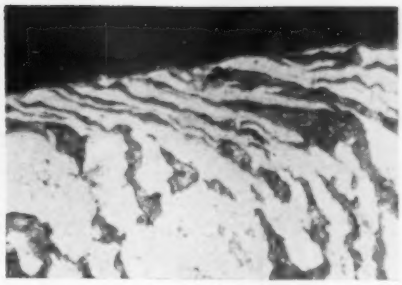


Fig. 4. Heavily distorted surface structure in 60 : 40 brass due to drastic machining on an automatic (× 1,200, lightly etched with 1 per cent ammonium persulphate).

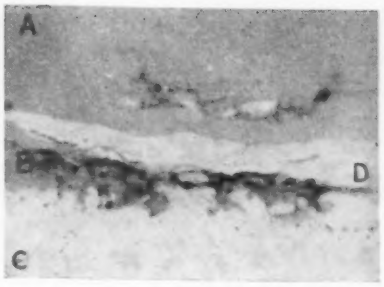


Fig. 5. Stress exfoliation of bright nickel plate and flow layer on 60 : 40 brass. A, Co-Ni plate; B, interfacial cracking; C, base metal; D, flow layer exfoliating (× 2,500, unetched).

crystals is that by deforming them by imposed work the crystals fragment into "crystallites" or minute replicas of the parent forms from which they originated. This fragmentation increases the hardness of the surface, and by a process of breakdown, the crystallites become smaller and smaller, until the original surface of the metal becomes covered with a series of layers composed of these minute fragments of the original crystal surface. The actual "Beilby layer" or truly amorphous (*i.e.*, non-crystalline) layer is situated at the surface extremity, and is usually of the order of 50 Angstrom units (Å) in thickness. This layer will not concern the present work on the surface of metals, as it is very difficult to conceive of such a layer existing on the extreme surface after anodic etching, especially when it requires 5,000 such layers superimposed in order to make up 0.001 in. thickness of matter. Although the Beilby layer is not vitally concerned in this work, its properties are of importance when dealing with extremely thin surface layers. The layers which play such an important part in the surface properties as far as the plater is concerned are situated in the zones directly below that of a true Beilby layer. These are capable of being resolved at high magnifications, and can be examined with advantage.

Appearance of Flow Layer

A series of flow layers on steel and chromium, are shown in Figs. 1 and 2, at 1,200 and 3,000 diameters respectively. These photomicrographs show the zone of plastically flowed crystallites which can be seen on the surface of a section of metal which has been polished by buffing or by rubbing, as in the case of a cylinder wall on which a piston has been working. The flow layer in Fig. 1 is composed mainly of crystallites, and has been formed by considerable tangential rubbing on the surface of a cylinder $\frac{5}{8}$ in. in diameter. The softer matrix of ferrite (white in the photograph) has been drawn out into long tapering threads, whereas the pearlite (the laminar constituent) has decidedly fragmented. The behaviour of a two-phase material is always characterised by the softer constituent displaying considerable plasticity, whilst the harder invariably fragments. A similar flow layer is found on the surface of 60 : 40 brass, where again a two-phase field exists. The condition in Fig. 2 is quite different, and although its form and characteristics are similar in all respects to the preceding types, it was produced by excessive rubbing under lateral pressure. The flowed layer illustrated in Fig. 2 at 3,000 diameters is particularly striking as it exhibits all the properties found in such layers. These properties are characteristic and in the example in question, the whole layer is stratified, and shows successive strata which have been superimposed due to the primary fragmentation of the parent crystalline structure and to the plastic deformation brought about by the work on the surface. The uppermost layers are severely cracked, exhibiting a fundamental property of brittle material, *viz.*, transverse fissuring, with distinct voids which are doubtless formed by the "bridging" of the fragmentary material. The adhesion between layers does not appear to be of a high order and there are distinct signs of dislocation in parts. The stratum situated directly in contact with the true crystalline material is the best established of the whole layer, but this shows a form of "granulation" and distortion, and it, too, exhibits the lack of true adhesion at the junction between the metallic crystals and the layer itself. The properties of such a layer are best understood if compared with those of pitch, which flows plastically under the influence of gravity, but which fractures easily if given a sharp blow, thus portraying two attributes, each the antithesis of the other, *viz.*, plasticity and brittleness.

The fact that a layer exists at all entails a plastic deformation, and that it crazes in a transverse plane requires the presence of non-yielding material; thus the layer possesses dual characteristics which can only be explained by the presence both of material capable of plastic working and of that which exhibits the properties of an amorphous body. This can be interpreted as being composed of minute crystallites (crystal fragments) separated by randomly oriented material (amorphous matter). This is by no means a "Beilby layer" in the true sense of Beilby's original interpretation of such a layer, but does present the possibility that the layer under discussion is a "partial Beilby layer," partially crystalline matter and partly amorphous material. Thus the result of working a surface into a polished plane produces a structure whose inherent properties differ considerably from those obtaining in the original true crystalline form. This worked surface varies in thickness very considerably in different metals, and from observations carried out on a considerable number of specimens, it would

appear that the thickness of the flowed layer is dependent upon the cold working properties of the metal concerned. Thus for the same amount of mopping, a layer on steel shows around 0.00025 in. thickness, whilst that on 60 : 40 brass is only 0.00004 in. The steel layer exhibits a greater degree of fragmentation and a compactness of structure, whilst the brass layer shows every tendency to craze and exfoliate, and exhibits a sharp line of demarcation between crystalline and flowed material. The chromium type of layer appears as an intermediate one between these two. This is not differentiating between the types of layers in a manner to suggest they have fundamental differences, as each possesses the identical properties except that the parent metal influences the final thickness of such a layer.

Stress Exfoliation

The process of electrodeposition depends for its successful operation on a system of well-tried factors of which chemical cleanliness is of paramount importance. The fact that an electrolyte is controlled, and that current density is correctly assessed, does not guarantee first-class results in practice unless the metal in its turn, is as precisely governed. The fact that such variables as those mentioned are capable of control does assist in allocating any fault to the true origin of that fault. Thus it is not difficult to ascribe any defect arising from lack of care in the overall control of the electroplating bath and the cleanliness of material to its correct source. Despite such a series of conditions which should produce excellent results, there is often that element of doubt as to the quality of plating resulting from even the most vigilant surveillance on the part of the operators. This doubt is occasioned by the possibility of the non-adherence of the plating either at the actual deposition stage or at some future occasion as that of a stored article, or one under actual conditions of service. There is only one variable of which the plater cannot be quite sure, and that is the actual surface behaviour. The amount of work carried out on a surface prior to any operations on the part of the plater is an unknown quantity as far as he is concerned. His job is to produce a sound plate, and he does his best to do so. The fact that a plate exfoliates or exhibits looseness of structure is very often as much the fault of the manufacturer as of the plater. Figs. 3 and 4 at 1,200 diameters, will illustrate this point clearly.

These photomicrographs show the surface section of a part machined on an automatic, the material being a typical 60 : 40 brass. The machining is very drastic and the surface is extremely distorted due to tool pressure without adequate cutting shear. Such a state of affairs is a frequent experience, and a machined finish of this nature is completely unsuspected in a plating shop. After mopping to produce a good surface finish, the actual surface, although exhibiting an extremely brilliant polish, invariably proves to be a most unsatisfactory base for electrodeposition. The reason is obscure unless very careful metallographic examination of a section of the plated surface is carried out. Several points must be borne in mind when interpreting results of such an examination; a brief outline of these can be stated as:

(1) Machining a surface entails the absorption of energy by the surface. The keener and cleaner the cut, the less energy is expended by the tool in overcoming the shear resistance of the metal. Drastic cutting speeds, combined with absence of tool keenness, produce a completely distorted layer of metal on the surface, composed of highly strained crystalline material, which has been plastically deformed into a series of waves which have very little or no adherence to the true crystalline material below. In exceptional cases, "bridging" or the forming of cavities in the layer occurs, and in very cold worked layers of this nature transverse cracks and fissures are invariably present.

(2) Polishing by the usual methods employed in a plating shop is closely allied to the latter condition in (1). The mop does not "cut" in the sense of producing shear failure as in the case of a normal edged tool. The brilliantly reflecting surface which results from mopping is produced entirely by plastic flow under pressure with severe slipping occurring in the surface crystals, but only actually on the surface or at the most a very minute distance below the surface itself. Hence the distortion of the material by the mopping is extremely localised. The fragmented crystal surfaces are smeared over the machined distorted layer and completely mask the effect of the unsatisfactory cutting, but do not adhere to such a surface.

(3) Cleaning takes place, which invariably includes anodic or cathodic techniques, and the upper flow layers are removed, exposing the lightly adhering polish layers which are superimposed on the distorted

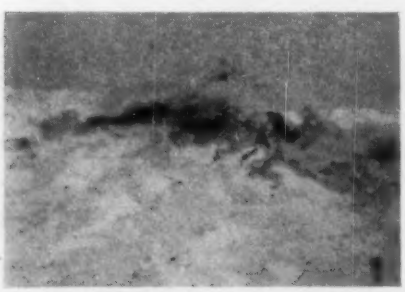


Fig. 6. Partial flowed and fragmented layer exfoliating from the true crystalline structure of 60 : 40 brass lying directly below (× 2,500, unetched).

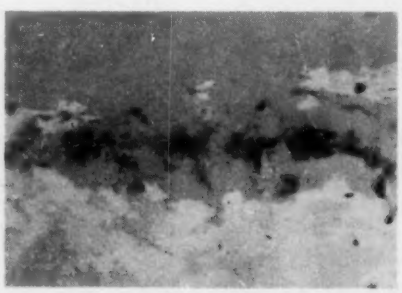


Fig. 7. Zone of true adhesion on the crystalline grains of the 60 : 40 brass, with a zone of interfacial cracking due to a portion of the flow layer in the immediate vicinity (× 2,500, unetched).

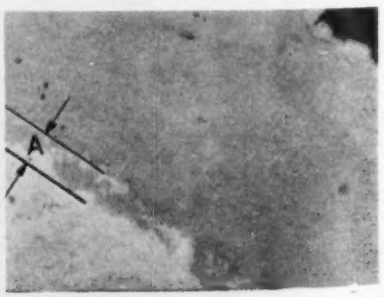


Fig. 8. Embryonic exfoliation crack along partial flow layer on a 60 : 40 brass forging carrying bright nickel plate and decorative chrome. A, "honeycomb" interface (× 2,000, unetched).

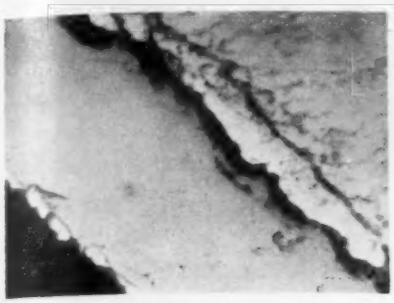


Fig. 9. Bright nickel plate and flow layer exfoliated from a 60 : 40 brass forging (× 2,000, unetched).

Fig. 10. Ragged type of interface showing cavities, A, caused by the flow layer; B, an adherent deposit on the crystalline surface at C on hot-worked 60 : 40 brass (× 2,200, unetched).

Fig. 11. Cracking and fissuring of deposit due to stress relief arising out of conditions as shown in Fig. 10, A, crack; B, 60 : 40 hot-worked brass base metal; C, Co-Ni plate (× 2,000, unetched).

layer. On completion of the surface cleaning it is as clean as a chemical or electro-chemical process can make it, and electrodeposition takes place.

(4) The plate itself under the above conditions exhibits either (*a*) looseness of deposit, or (*b*) blistering, or (*c*) partial exfoliation with an extremely thin dull deposit of electroplated metal on the exposed surfaces, or (*d*) the plate just sheds itself completely, leaving a discoloured surface beneath. This form of exfoliation can be termed "stress exfoliation," as it is due entirely to the relief of locked up stresses in the distorted surface layer originally produced by rough machining methods.

Several cases of this nature are shown in photomicrographs Figs. 5, 6 and 7 at 2,500 diameters. The 60 : 40 brass is on the lower portion of each photo, the exfoliated plate is seen above, and due to the difference in reflectivity between the nickel plating and the 60 : 40 base metal, the plate appears dark. The specimens must be examined unetched and the standard of metallographic finish should be as high as possible, as the only possible way to observe these interfacial conditions is by direct contrast between the plate and the base itself. Etching is selective, and hence at very high magnifications the slightest difference in level will effect an "out of focus" state, and observation becomes impossible. The specimens show how an over-energised layer, produced either by rough machining or by direct polishing methods, is very unstable and will relieve its internal energy by either cracking or actual flaking off. The flow layer is seen in Fig 5 to be completely divorced from its original position. This condition is not surprising when Figs. 1 to 4 are examined, as an identical state of affairs obtains in those as in the actual plated surface. The dark network which also exhibits fragmentary pieces of plate and brass is mainly composed of minute cracks which are a direct result of stress relief, and Fig. 6 shows how the flow layer is lifted by the generation of cracks along the plane of the interface. Fig. 7 shows a zone which exhibits normal crystallinity and with traces of a flow layer in its vicinity: and due to the potential conditions between the two states, the nickel plate itself, although apparently adhering to the crystal faces, cracks along the gap between the non-continuous flow layer. Referring again to Fig. 5, the flow lines and minute contour cracking can be seen in the section of the brass layer which has lifted, and the actual distance between the layer and the crystal surface below is of the order of 0.00002 in. Hence such a movement is undetected by normal observation; but the fact remains that it constitutes a void or discontinuity between the plate and the base, hence exfoliation must follow as an inevitable result.

This type of exfoliation is a direct result of interfacial breakdown, and is accompanied by cracking in the extreme surface layers of the base metal, with corresponding zones of hairline cracking in the plate adjacent to the interfacial layer. The appearance of this form of breakdown is shown in photomicrographs, Figs. 8 and 9, each at 2,000 diameters. Fig. 8 shows a typical example of embryonic cracking occurring along the plane of the first true layers of plate. An examination of the interface itself is illuminating, as it is seen to be of an undulating character, due doubtless, to the presence of non-continuous flowed surface metal, together with zones of true crystalline material. The action of surface cleaning, including an anodic etching, has only partially removed the flowed layer, and so brought about this condition. From previous observations on the structure of flow layers, it was emphasised that one particular characteristic of such layers was that of extremely poor surface adhesion between the flow layer and the true crystalline material below it. Such a property enhances the formation of a "honeycomb-like" interface, in which the initial plating appears to have actually entered into the surface of the base metal, suggesting the possibility of a degree of penetration taking place. However, the presence of interstitial voids of comparatively large dimensions (when compared to those of the depositing ion) leads to a conclusion that these initial ions migrate via the voids into the minute spaces which exist between the flow-layer and the crystal surfaces, due to surface forces, bearing in mind that these zones of little or no contact are non-continuous. Hence the characteristic appearance of the true interface. The significance of such a surface condition lies in its dual nature, possessing both the properties of accepting plate in the crystalline areas and opposing the deposition in those of random formation, or better known as flow layers.

Thus the interface itself depends entirely upon the constitution of a surface, and when such a surface is entirely composed of regularly oriented matter (*i.e.*, crystalline), deposition is continuous and regular; but when such a surface is composed of randomly distributed atoms or molecules, then the deposition is ragged and irregular. On the other hand, as in the case of Fig. 8, where both random and truly oriented material lies in juxtaposition, then the interface becomes somewhat indiscriminate and appears as a zone rather than a well-defined line of demarcation.

The appearance of the ragged type of interface is shown in Fig. 10 at 2,200 diameters. The flow layer is seen on the surface and the plate is completely divorced from it; whilst in spots where the flow layer has been removed, the plate is seen to adhere perfectly. The minute hair cracking which occurs in the adjacent plate to such an interface is seen clearly in Fig. 10, and this type of breakdown eventually causes a serious form of cracking as that shown in Fig. 11, which completely shatters the layer of plate and results in exfoliation. This takes place after the lapse of time, and the surface stresses locked up in the minute layers of the flow layer relieve themselves, usually at the expense of the immediate layers of plating and often by actual peeling off of the flow layer itself, in which case the plate, although not actually fractured, is exfoliated together with the flow layer, as seen in Fig. 9 at 2,000 diameters.

Fig. 12 shows a section of the electroplate which has been completely shed by the relief of stress. The section is interspersed with minute areas of hair cracking, and major cracks occur further up in the region of the nickel surface. A minute fragment of the flowed layer from the base metal is seen on the underside of the plate and is recognised by its characteristic brightness.

Pinholes

Another feature which is a plater's bugbear is pinholing of the plate, and this again is produced by surface conditions. The process of mopping, with intermittent pressure application, sets up waves in the surface flow, examples of which are seen in Figs. 13 and 14 at 2,000 diameters. Plating is of such a nature that it does not want to deposit on to sharp edges or peaks. It will deposit on the slopes of such peaks, and by so doing forms a concentric structure which persists throughout the thickness of a coat, producing a circular hole reaching from the crest of the wave on the surface of the base metal to the uppermost layer deposited. There is usually a field of crazing at the surface of the plate, particularly if, as in the case of nickel, a chrome layer is deposited on the surface itself, and in the example shown it is seen extending from the chrome layer to the walls of the pinhole. This condition of pinholing, although not a direct contributory cause of exfoliation, is definitely an indirect one.

In Fig. 13 the effect that undermines the plating and indiscriminately attacks both interface or plate alike is seen clearly, and the condition is indicative of the origin of chemical or corrosion exfoliation. The portion shown near the brass illustrates the manner in which the plate is literally rejected and is unable to establish an interface by reason of surface influence. The behavior of the chrome layer at the surface of the nickel coat is interesting, too. The nature of the nickel deposit is such that it induces the chromium ions to follow its intrinsic formation and thus sustain the pinhole cavity into the extremities of the plated layers. The remarkable influence of original pattern in the plate on any superimposed deposit under these circumstances is such that if, by chance, the chrome succeeded in bridging the minute orifice of the pinhole, it would subsequently craze and so re-establish the tube up to the true surface layers. The manner in which the chemical or corrosion attack is effected by pinholing is clearly seen in the mircograph, and the ease with which both plate or base metal is deteriorated by this attack can be appreciated by reference to the left of the pinhole itself.

Corrosion Exfoliation

The presence of such holes provides a line of easy approach of corrosive liquids or reactive gases, which will undermine the adhesion of the plate by chemical action. A particularly good example of this form of exfoliation, which can be termed "corrosion exfoliation," is seen in Fig. 15 at 2,000 diameters. The pinhole has become a comparatively large cavity, and the

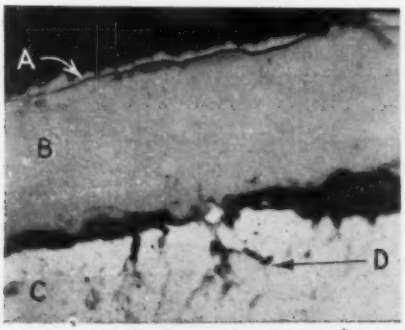


Fig. 12. Severe exfoliation, due to both flow layer and stress corrosion. A, crazed chrome deposit; B, dull nickel plate; C, 70 : 30 brass base metal; D, grain boundary breakdown due to stress corrosion (× 2,000, unetched).

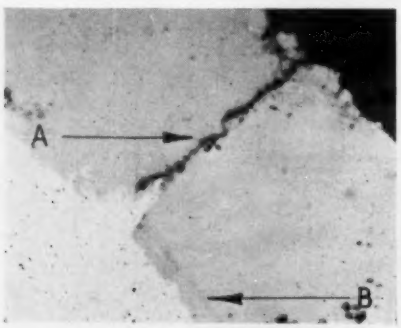


Fig. 13. Section showing pinhole, A, through bright nickel plate caused by wave on surface of 60 : 40 brass due to mopping; B, embryonic exfoliation crack (× 2,000, unetched).

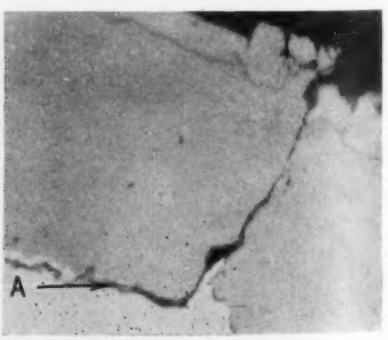


Fig. 14. Embryo exfoliation due to influence of pinhole on highly stressed base metal surface. The path of attack is shown at A (× 2,000, unetched).

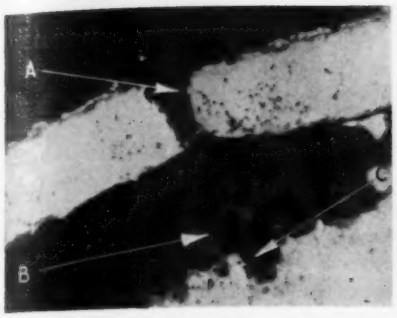
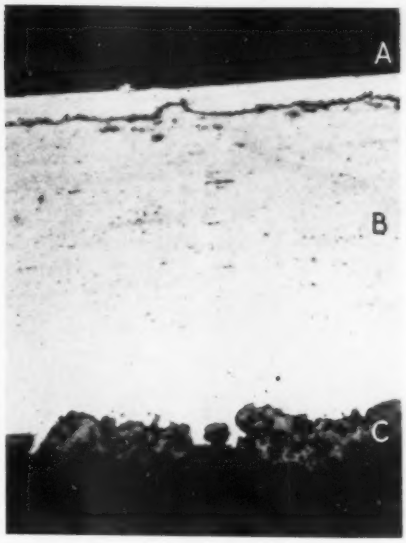


Fig. 15. Section through corrosion spot on dull nickel deposit with decorative chrome layer. Base metal 70 : 30 brass sheet (20 swg.) forming a radiator shell. A, original pinhole greatly enlarged by corrosion; B, actual chemical compound arising from decomposition of interface; C, active pitting in brass surface (× 2,000, unetched).

Fig. 16. Section of dull nickel deposit, with a layer of decorative chrome, exfoliated from a 60 : 40 brass sand-cast cap. A, decorative chrome; B, nickel plate; C, chemical compound arising from decomposition of interface. Note the erosive nature of the attack on the nickel (× 2,500, unetched).



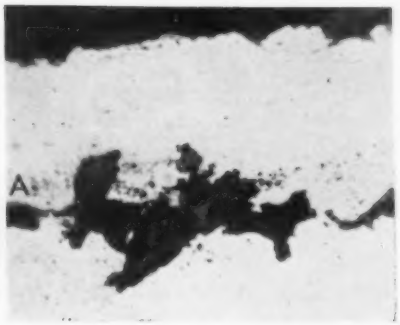


Fig. 17. Section through a dull nickel-plated radiator shell (70 : 30 brass sheet). Effect of pinholing on interface after a period of storage prior to assembly. The interface chemical attack is shown at A (× 2,000, unetched).

products of reaction due to the ingress of reactive matter have attacked and pitted the surface of the base metal with the formation of a compound which appears as a network of featureless matter in the micrograph. This reactive matter also attacks the plate, eroding the line of adhesion and pitting the deposited layer throughout its thickness. The pressure exerted by the formation and heat of formation of such a compound is sufficient to lift the plate clear of the base metal, thus exfoliating it. Very often the exfoliated plate is found to be entirely covered on its underface with the products of such a reaction, and the eroding nature of the action is evident from the extremely ragged section of such an exfoliated layer. An example of this type is seen in Fig. 16 at 2,500 diameters. The chemical compound formed by the reaction on the interface is seen adhering to the lower portion of the plate, and the erosion brought about by the corrosive nature of the reaction can be visualised by the broken-up appearance of the edge which originally formed part of the interface.

Blistering

The nature of this form of exfoliation is such that a pinhole in the plate can be responsible for a local type of exfoliation, usually known as blistering. This phenomenon is truly a bugbear because of its appearance long after the plated article has been in service, although it is equally possible to find it shortly after removal from the plating vat. In any case it ruins the plate, and when blistering is found after storage or in service it usually is of a wholesale nature, whereas that occurring directly after deposition is generally very localised. The appearance of blistering after the lapse of a considerable time is shown in Figs. 17 and 18 at 2,000 diameters.

The reactive matter which finds its way into the interface via pinholing, seeps along the plane of the interface and sets up large areas of reaction. These areas show spots of concentrated attack, which suggest that, thermodynamically, the surface of the base metal is unstable, having zones of higher energy than others in their vicinity. These zones of higher free energy react to a greater degree than those of lower free energy. In other words, zones which are crystalline possess the least free energy, whilst those composed of random or flowed material possess high free energy. This energy is synonymous with chemical affinity, and it is not surprising that reactions are most violent in selective areas. The above photo-micrographs show this condition as it exists on an interface, and the spots where reaction is a maximum produce the "lifted plate" or blisters. The sections through these zones, particularly in Fig. 18, illustrate the mechanism of the formation of such blisters, and the voluminous compound formed between the plate and the base metal explains their nature without description. The extremely violent erosion of the underface of the plate is, however, significant, and the manner in which these blisters burst and the exfoliated plate folds away from the fissure can be understood when examining the examples quoted.

The Influence of Stress and Corrosion

The presence of both stress and a corrosive medium produces a somewhat different form of exfoliation. The very acid types of plating solutions often give rise to this phenomenon, particularly in the presence of minute stress cracks lying in the immediate surface of the base metal. This condition has often been met with when machined components have been "stopped off" with an acid copper deposit in order to prevent carburisation taking place on the surface so treated. The components are usually finely machined and ground finished. The action of a grinding wheel is essentially that of removal of metal by abrading, and hence the choice of a wheel for a particular steel becomes very important. Too hard a wheel glazes, and so effects a severe rubbing without removal of metal, whilst on the other hand too soft a wheel abrades but wears very rapidly, giving rise to severe surface heat gradients. These heat gradients, in the

immediate surface zone, cause transformations in the steel, and by so doing produce the well-known grinding cracks so often seen in finished components. The visible grinding cracks are safe because they are allowed for, and their removal and subsequent diameter build-up by any of the hard deposit methods are equally well known. The unfortunate possibility in the case of grinding is that of sub-surface hair cracking which is not visible. An example is shown in Fig. 19 at 1,500 diameters. The cracks are very minute and in the main lie beneath the surface and very often at the transition zone between the transformed surface metal and that of the unaffected structure beneath. These cracks act as capillaries and retain the acid electrolyte which, on being heated, seeps out and undermines the plate by corrosive attack on the grain boundaries of the plate.

The presence of heat, particularly of high temperatures as in carburisation, recrystallises the plated layer and this in itself assists such an attack. This form is shown in Fig. 20 at 3,000 diameters. The severe attack on the grain boundaries can be seen (in both cases), and as the original plate exhibited excellent adhesion and gave little evidence of porosity, the exfoliation was unexpected. This case is quoted as its origin explained the failure of a series of carburising operations, and hence provision was made to prevent their recurrence.

Closely allied to this form, but totally different as regards its application, is the depositing of a very thin coat of brass on steel to effect the adhesion of a rubber moulding, a frequent requirement in the automobile industry. In order to assess the efficacy of the bond between the rubber coat and the metal, a destructive test is demanded which amounts to tearing off the rubber and by so doing determining the adhesion. In a recent case of this nature the rubber appeared to have a very poor bonding, but on examination it was found that the brass plate had torn away from the steel pin and the unsatisfactory adhesion was due entirely to the exfoliation of the brass plating. This extraordinary condition was difficult to understand as other components undergoing brass plating gave very satisfactory results and was particularly puzzling as every component other than these pins gave no trouble at all. A careful metallographic examination of the surface metal was carried out and it was found that the pins were made of a high-class oil hardening steel, and that a fine machine finish was supplemented by surface grinding. The wheel used was either glazed or was too soft as a severe flowed layer existed on the surface and this layer was crazed and only partially adhering to the normal crystalline structure beneath. The photomicrograph, Fig 21 at 2,500 diameters shows the condition. The plating is very thin, an essential for the bonding technique used between the rubber and the metal, being of the order of 0.00025 in. thick. Such a thin plate if deposited on an energised surface will fail very quickly due entirely to interface breakdown, the nature of which has already been discussed. Fig. 21 shows a portion of the flowed layer with a fissure developing between the crystalline material and the layer and a trace of the original brass plating is seen on the extreme right of the photo.

Fig. 22 at the same magnification shows the actual exfoliation of the brass plate. The extent of cracking and fragmentation of both steel surface and that of the plate itself gives a clear indication as to the extent of these locked up stresses, and the results of the effect when relieved. The minute cracks had retained cutting fluid which exuded during plating and bonding and contributed to the undermining of the deposited layer. It is difficult to define this type of exfoliation, but undoubtedly the internal stresses set up by the unsatisfactory surface finishing are the primary reason of failure. The fact that oil was held by capillary action, and that it subsequently spread into the interstices of the layer is a secondary reason, and the presence of such a flow layer with its unsatisfactory properties is an essential before any other unwanted feature can contribute its quota to the failure.

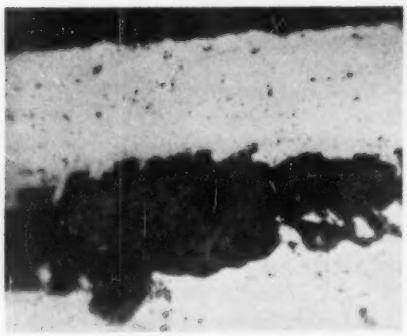


Fig. 18. A similar condition to that shown in Fig. 16 but in a more advanced stage (× 2,000, unetched).

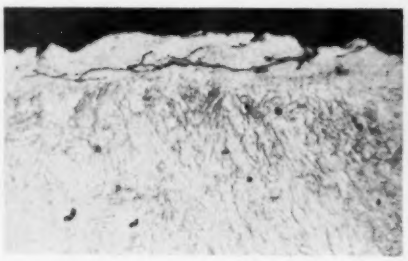


Fig. 19. Sub-surface cracking in a carburising Ni-Cr alloy steel (× 1,500, very lightly etched with 1 per cent nital).

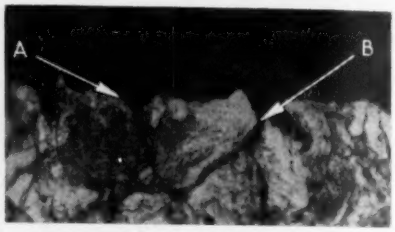


Fig. 20. Section of acid copper deposit which exfoliated from surface of the steel shown in Fig. 19 as a result of stress corrosion. A, original interface, now in a state of partial disintegration; B, grain boundary breakdown due to stress corrosion at interface (× 3,000, unetched).

Summary

The mechanism of exfoliation is not a simple one. The interface conditions as regards the forces acting between the base metal surface and the deposited plate can only be attributed to that of actual cohesion between the metal atoms or molecules. Our present state of knowledge of the physics of metals is growing, but it is a mere glimpse of what really takes place rather than a knowledgeable view. Hence it becomes difficult to dogmatise and give statements which are irrefutable. However, by careful observation using a large number of specimens, the behaviour of surfaces

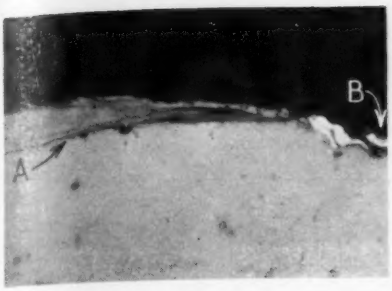


Fig. 21. Appearance of surface of oil-hardened Ni-Cr-Mo steel pin surface ground and brass-plated for rubber bonding. Failure of bond was due to stress relief at surface of steel resulting in the exfoliation of the brass plate. A, crack due to stress relief; B, fragment of brass plate (× 2,500, unetched).

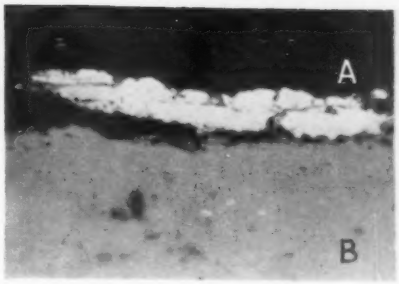


Fig. 22. Similar conditions to those in Fig. 21, showing exfoliation of the brass plate and fragmentation of steel surface due to relief of locked up stresses (× 2,500, unetched).

can be fairly well assessed and to some degree certain properties can be foretold. The three main types of exfoliation, *viz.*, stress exfoliation, chemical or corrosion exfoliation, and the combination of both which can be termed stress-corrosion exfoliation are so prevalent that a comparison between them would be advantageous. Three photomicrographs, Fig. 23, 24 and 25 at 2,500 diameters show actual conditions of exfoliation with the plate just lifted from the base metal in each case. The gap between the plate and the base would not be visible to the naked eye as it is of an order of from 0.0003 to 0.004 in.

Fig. 25 shows the condition found in a purely stress exfoliation. The base metal shows the presence of a flow layer of the order of 0.00005 in. in thickness which is of the usual order found in brass or for that matter all of the copper rich alloys. The gap shows minute fragments of metal which are due to support afforded in the third dimension and are sections of torn layered material. The evidence of a third-dimension (*i.e.*, depth) is amplified in high magnifications, and a degree of "out of focus" effect is due to material lying beneath the plane of the photograph. The plate is very rough on its underside and exhibits edge crazing. This is the direct result of stress relief, and in the absence of any corrosive medium, such a form of outlet for internal stress is usual. Thus the plate becomes divorced from its base metal by virtue of minute surface cracking. Fig. 23 shows chemical or direct exfoliation. In this case a corrosive medium has found access to the interface and has reacted in selective spots, resulting in severe pitting, the product of the reaction being evident by its retention in the corrosion pits themselves. Detached fragments of the base metal are seen in the gap, and are the result of the surface disintegration, and a degree of pitting and crazing along the plate interface is evident. In this case exfoliation results because the interface is eliminated by the chemical reaction. Fig. 24 shows a combination of both types, which results in exfoliation by reason of stress cracking and chemical breakdown. The crazing in the plated layer is very evident and the formation of a chemical compound is seen present in the gap, whilst the base metal interface shows severe fragmentation of the flow layer.

A comparison of these three effects shows the complex nature of exfoliation of the usual type met with under industrial conditions. The relief of stress can be understood by reference to the behaviour of massive metals in the same manner. This condition is very well known and actual methods for the relief of stresses slowly, without the formation of cracks, are used every day in industrial practice. Such methods are not available to the plater as he is concerned with plating and not dealing with the problem of internal stresses. His only remedy to eliminate surface stress is to etch off the layer of metal responsible for this condition. The generous etching of surfaces should be encouraged providing that adequate control is exercised to prevent pitting of the surface. A well-controlled etch will limit pitting to a miximum depth of .00002 in., which is comparatively shallow, and the initiation of a stable plate will be insured by this method. An example of a very short exposure of such a surface to a plating solution is shown in Fig. 26. The time of exposure of this specimen was of the order of one second, and the plate is seen to have adhered firmly to the walls of the minute pits produced by controlled etching. These walls are sections of truly oriented matter, that is, crystalline, and the crystalline state is one of lowest internal energy and hence stability of plating results. The furtherance of this discussion is a subject of another paper, but has a very definite bearing on the present subject.

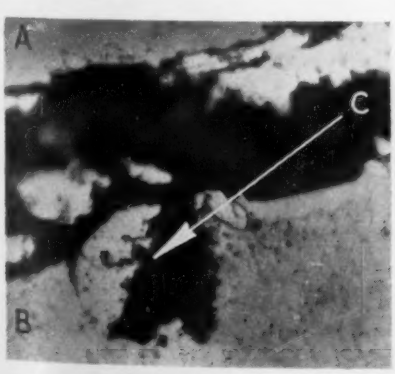


Fig. 23. Exfoliation due to chemical influence and pinholing. A, deposit; B, base metal; C, typical corrosion pitting (× 2,500, unetched).

Fig. 24. Exfoliation due to both chemical and stress influence. A, deposit; B, base metal; C, chemical decomposition; D, torn and fragmented flow layer (× 2,500, unetched).

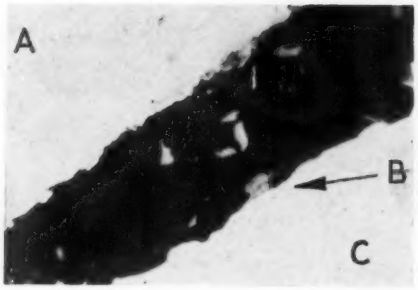
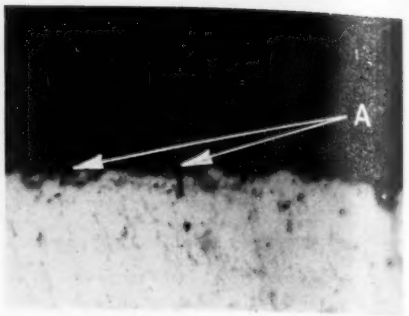


Fig. 25. Exfoliation due to influence of a flow layer. A, deposit; B, flow layer; C, base metal (× 2,500, unetched).

Fig. 26. Inception of an interface. Co-Ni plate deposited for one second on anodically etched 70 : 30 brass sheet. A, Co-Ni deposit on exposed crystal faces in minute etch pits (× 2,500, unetched).



Exfoliation of Lead-Bearing Brasses

The plater is liable, in his varied practice, to encounter a little known form of exfoliation which takes place on lead-bearing alloys of the free-cutting type—usually the brasses. The presence of lead in the composition of a copper rich alloy has for some time been suspected as a contributory factor in exfoliation. A study of these alloys was carried out to ascertain the effect of lead in the form of particles and, as is very often the case, in the form of minute hair-line stringers. The particle effect was found to be of little danger and plate was produced on hot pressed brass parts and on die castings containing dispersed lead particles without any alarming results. The matter, however, became serious when stringers of lead were situated in the immediate surface layers and a complex action was found to take place with exfoliation of the plated layer. A photomicrograph of this is shown in Fig. 27 at 2,500 diameters. It is rather difficult to describe the action taking place at the interface under these conditions. A large number of cases were examined and the only conclusion that could be made was that the lead diffused into the initial layers of plate. In some cases nickel has been found to have completely replaced the lead in the stringer and the lead appears as a dispersed phase in the plate adjacent to the interface. In others the lead has dispersed into the nickel leaving a void where it was previously situated. The two micros shown indicate this condition. The dark cloud, showing some tendency to exhibit characteristic patterns, is bounded by very distorted nickel layers. Several islands of uncontaminated nickel are seen, and are surrounded by a network of spongy nickel in which lead appears to be held interstitially. The divorcement of the plate from the base metal is due to the migration of the lead, and it is difficult to explain such mobility of atoms at the temperatures encountered in a plating vat. The research work on this condition is proceeding.

Conclusion

The mechanism of exfoliation has been reviewed in the light of research covering several years. The process used has been mainly metallographic and the results appear to suggest that this method of attack could be advantageously developed. The difficulty of reproducing a large number of photomicrographs by printing limits the range of conditions which would be portrayed. The photographs shown throughout this paper have been chosen as representative from 1,460 records, and hence the choice has been no easy matter.

The author wishes to express his sincere thanks to his assistant, Mr. P. Bott, who has worked extremely hard to produce an exact replica of the image shown by the microscope. Thanks are also due to Messrs. W. Watson & Sons, Ltd., the makers of the microscope, for their assistance in supplying lenses of the highest accuracy for the work carried out. Finally, the author wishes to express his thanks for permission on the part of The Rover Company, Ltd., to reproduce micrographs taken in the course of research work carried out on their behalf.

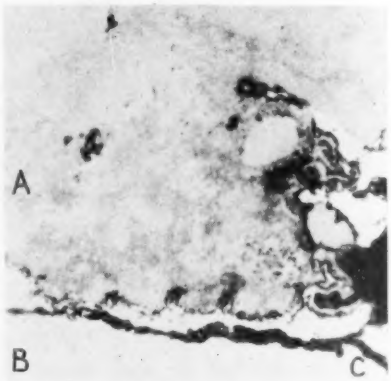


Fig. 27. Influence of lead stringers in free cutting 60 : 40 forged brass. A, spongy nickel at interface; B, base metal; C, original lead stringer (× 2,500, unetched).

Demineralization of Water

By Dr. F. R. Morral, *American Cyanamid Company, Stamford, Conn.*

AN OPERATING executive of a metal finishing concern meets a friend, who is a consulting engineer, after a recent technical gathering. After a friendly greeting, the conversation goes something like this:

FINISHER: Tell me, I hear a lot lately about demineralized water. What is it? What does it do? Do you expect it could be useful in my plant, and where?

CONSULTANT: You ask many questions at once, my friend! Let us take them one by one. Demineralized water (D.W.) is water that is chemically equal to distilled water. All the salts, minerals and chemical compounds have been removed.

FINISHER: How can you tell they have all been removed?

CONSULTANT: The D.W. may be sent to a chemical laboratory for analysis. Ions, cations and anions, which make up chemical compounds, will be checked for and found absent. An easier method to check the degree of demineralization is by measuring the electrical resistance of the water. The more salts that are dissolved in the water the higher is it electrical conductivity.

FINISHER: Yes, I realize that. I was told that some demineralizing units have a resistance meter.

CONSULTANT: Yes, that permits automatic control of the units. It also permits one to obtain water of the degree of purity desired.

You want to know what D.W. does? This goes together with your question on whether D.W. would be useful in your plant and where. Let me ask you a question: do you use distilled water?

FINISHER: Yes, we use some . . . we would use much more if it were cheaper.

CONSULTANT: Well, these are the places where you want to use D.W.—wherever you need a high quality water, free of salts, or where you wish the salts reduced to lower values. The cost of D.W. may be from 10 to 98% less than that of distilled water, and you need no stills, steam, or government permits . . . and it is made at room temperature. Where you need a water of constant composition, and let me remind you that in your community, the salt content of the water changes from day to day, a demineralizer will deliver water of the composition you want . . . whether it be a maximum of 1 ppm. or 20 ppm. of salts. The cost of the chemicals is approximately 6c per 1000 gallons for each 100 ppm. removed.

FINISHER: That cost figure makes it sound interesting. I'll have the chem. lab. check up on our water. Some of the fellows think that some of our streaky work in the plating shop is due to water. We better follow it up. It is expensive to reject, strip, and reprocess. Tell me, where has this D.W. been used?

CONSULTANT: Several papers have been published on the subject. *Hervig*[1] obtained stain-free, bright nickel plate by using D.W. The stains, he determined, were produced by the solids in the water. Other advantages he found were brighter and more easily buffed deposits when D.W. was used in making up plating solutions, make-up water and also in rinses. Further, using this water he was able to use higher temperatures with higher current densities without rough nodular deposits. He sums it up by saying that D.W. is not a cure-all and that good plating practices are imperative, but because higher quality and increased production often result from the use of treated water, it is a tool that metal finishers can profitably investigate.

FINISHER: In other words, he finds that D.W. is useful for preparing better cleaning, plating, and rinsing solutions?

CONSULTANT: Yes. *Morral*[2] has described the uses for demineralized water in the electroplating industry and in the wire mill.[3] To mention a few other examples . . . a manufacturer plating silver on various engine bearings found it necessary to use D.W. in his silver plating baths and for washing them.[4] Costly buffing and cleaning operations were eliminated and better adhering plates were obtained. In mirror silvering, the presence of chloride and other solids in the water spells the difference between good and bad mirrors. Recognizing this, mirror manufacturers used distilled water for years; within the last few years, scores of them have switched to demineralized water and lowered their production costs considerably.

D.W. was found indispensable in a large aluminum anodizing department for aircraft parts,[4] rinsing of aluminum parts after alkaline cleaning,[5] and quenching of aluminum alloys after heat treatment. The salts in the raw water caused etching and corrosion of the finished product.

On plating zinc on wire in one Midwest plant, demineralized water is used for the pickling, plating and rinsing solutions. It improves the current efficiency and makes possible a bright, non-streaky zinc surface.

FINISHER: Would D.W. be useful in a porcelain enameling plant?

CONSULTANT: Yes. Dissolved salts in the water used with the frit may impart a temporary set to the coating, which has caused erratic behavior during application.

This will interest you. A comparison has been made

on the use of Chicago tap water vs. demineralized water in copper plating. With the latter a remarkably superior brightness was obtained, and as I have mentioned before, a rinsing with D.W. actually stopped streaked work.

FINISHER: How can I interest my management in this type of water?

CONSULTANT: You buy chemicals, soap, plating salts, anodes and many other materials to specifications. Water is the chemical you use in largest amounts. Even with your best plating know-how, this water may be instrumental in causing blisters in your plates, poor adhesion, tarnished coatings, excessive corrosion, and low efficiency. Don't you think you should check your water and set a specification for it if it needs it?

FINISHER: Yes, I see your point.

CONSULTANT: You train and hire the best you can get in personnel, have automatic controls for temperature, pH, voltage, current densities. Management expects you to reduce costs, and considering all the above one way is by reducing rejects and the costs of reworking them.

FINISHER: That sounds logical. Tell me, is this D.W. used, or has it been suggested for other applications in the metal field?

CONSULTANT: *Pliny* recorded the difference between the waters from various rivers. *Dittmar*[6] discussed the need of pure water in the precision casting industry.

Demineralized water has found no use in the quenching of steel, although I can see where it might be useful in certain quench tanks, although the removal of gases is more important.

The pollution of streams by industrial wastes is a serious problem which is causing some worry to industrial management. Demineralizing units may be used for the removal of cyanide from plating wastes. In some cases, the cyanide can be recovered and reused. The recovery of chromates, copper and other metals, particularly the costly ones, is being studied and it shows promise.[7] But the problem of plating waste disposal as well as that of recovery of metals requires more research and development work. Even though theoretically possible, the ion-exchange process is not always the most economical solution.

To summarize, I would recommend the use of demineralized water wherever one has used distilled water and wherever one would like to have a quality-controlled water . . . whether the specifications for the treated water read 0 ppm. of salts, 20, or 100, as the case may be. The demineralizing units may also find use for recovery of metals, the removal of plating chemicals we are not supposed to throw into our rivers, and for treating water which we want to recirculate and reuse. Another possibility being considered is the removal of chemicals from rinse water.

References

1. *R. S. Hervig*, Iron Age, March 27, 1947, p. 48.
2. *F. R. Morral*, Water and Electrodeposition, Metal Finishing, Nov. '46, 472.
3. *F. R. Morral*, Demineralized water in the wire mill. Wire & Wire Products 21, 1946, 759, also 22, 1947, p. 54.
4. *W. S. Morrison*, Paper and Trade Jl. Jan. '45, p. 31-2.
5. *R. S. Hervig*, Iron Age, July 11, 1946, p. 58.
6. *F. Dittmar*, Iron Age 8/2/45, 52.
7. *American Electroplaters Society, Proc.* Tech. Sess. 1947, v34 1948, p. 249.

FLUID MECHANICS

(*Continued from page* 59)

the *Reynolds Number*. It is mathematically defined as

$$R_e = \frac{DUp}{Z}$$

where D is a measure of surface length in contact with the fluid (in the case of pipes, the pipe diameter), U is the velocity of the fluid past the solid surface or pipe wall, p is the density of the fluid, and Z the viscosity of the fluid.

The Reynolds Number is what is known as a dimensionless ratio; that is, all the units in which the various factors are measured cancel each other out, leaving a simple number as a result. In a given case, flow above a certain value of this number is considered turbulent and below that value, viscous. It is one of a series of dimensionless ratios which are frequently employed in fluid mechanics and hydrodynamics. Its importance in fluid flow is easy to understand because it can be shown that in general the force resisting motion between a fluid and a solid suspended in the fluid or in contact with it, is given by the expression

$$\frac{F}{A} = \frac{pU^2.f(R_e)}{g}$$

where F is the resisting force, A the area of the surface in contact with the fluid, U the velocity of motion, g the gravitational constant, p the density of the fluid and f (R_e) means a function of the Reynolds Number, the function being determined by the geometric shape of the solid and its roughness.

It is the amount of this resisting force that determines the speed of ions in a plating solution and it is the amount of this resisting force that helps determine the thickness of the liquid film in viscous flow, on a solid immersed in a fluid, where relative motion exists between the two.

The subject is one of extreme complication and highly advanced mathematics but it has been shown that very approximately the thickness of the viscous film on a solid in contact with a fluid where there is relative motion between them, varies inversely with the Reynolds Number or

$$d \propto 1/R_e$$

This relationship is of great importance in high speed plating for on it depends the limiting current density that can be used in a plating bath, as will be shown in the concluding installment of this series, which will deal with agitation of the plating bath.

(*To be concluded in next issue*)

Shop Problems

Abrasive Methods—Surface Treatments—Control
Electroplating—Cleaning—Pickling—Testing

METAL FINISHING publishes, each month, a portion of the inquiries answered as a service to subscribers. If any reader disagrees with the answers or knows of better or more information on the problem discussed, the information will be gratefully received and the sender's name will be kept confidential, if desired.

Black Finish on Soldered Brass Parts

Question: We wish to black finish brass parts that have been assembled by soft-soldering. Everything we have tried so far has caused the soldered area to show. Can you tell us how to eliminate this problem?

J. R. B.

Answer: One way to overcome this problem is to copper plate the assembled parts and use a blackening bath for coloring the copper plating. Brass plating can also be used. The names of manufacturers of blackening baths for this purpose are being sent to you. Of course, the usual non-proprietary oxidizing solutions, such as potassium sulfide, may also be used.

Brown Color on Brass

Question: Can you suggest a procedure for coloring yellow brass to a brown color. Because of the nature of the parts, long bars, any solution used would have to be brushed on at room temperature.

A. M. S.

Answer: For a brown color on yellow brass, the following treatment may be used;

1) Clean bars thoroughly first with carbon tetrachloride or other good grease remover. All grease and oil must be removed.
2) Brush on the following solution;

Sodium Bichromate	20 oz.
Nitric Acid (conc)	2½ fl. oz.
Muriatic Acid (conc)	¾ fl. oz.
Wetting Agent	1/10 fl. oz.
Water	1 gallon

The treatment time is several minutes. When sufficient depth of color has developed, rinse off the parts well and dry. A clear coat of lacquer should then be applied.

Stripping Rhodium from Nickel Plated Articles

Question: Would you kindly let us know if there is a way to strip Rhodium plating?

R. J. R.

Answer: In order to strip rhodium, the part is made anodic in a solution of 55° Baume sulfuric acid, at 7 volts. The temperature of the acid strip should be held between 90-100°F. to avoid pitting and attack on the base metal. The time of stripping will depend on its thickness, but roughly 3½ millionths can be removed in about 50 minutes. Water must be rinsed off the parts before applying the current, as it also causes pitting.

Bright Silver Plating

Question: Can you send me the formula for a bright silver plating solution? We would also like to know how to remove an excess of brighteners from our present silver solution.

F. J. B.

Answer: Silver cannot be plated full bright as we know it for other metals such as copper and nickel. The best that can be done is a semi-bright deposit, which requires some buffing or scratch brushing to bring up the full brightness of the silver.

The best way to eliminate the excess of carbon disulfide or ammonium thiosulfate from your present solution is to operate the bath for several weeks without any additions of these materials. They will gradually be used up by oxidation or chemical reaction.

Recently a method has been perfected whereby the silver plating and electropolishing is completed in the same cycle. This is a patented process and is being used in the tableware industry. A conventional cyanide bath is used, with the parts being made the anodes, after plating is completed, and a short period of electropolishing follows without removing the parts from the plating racks.

Plating Tank Liners

Question: What type of plastic do you recommend for placing between the anodes and sides of the tank in a chrome solution?

F. J. M.

Answer: For this type of application I would recommend using a glass sheet instead of a plastic material, as most of these latter materials will in time deteriorate due to the high temperature or by chemical action. For greater strength and durability, you should get glass that has been reinforced with wire.

Plating Waste Disposal

Question: We are interested in methods for neutralizing cyanide and other wastes from our plating operations so as to avoid further pollution in our district. Can you give us the required information?

D. J. K.

Answer: At the present time the A.E.S. Research Committee is investigating the whole field of plating waste treatment methods through one of its Research Projects. Each plant's problem must be given individual attention, as there are many variables that must be carefully considered before any specific recommendations can be made. However, a number of successful installations have been made. Names of firms specializing in this work are being sent to you.

Barrel Nickel Plating

Question: We obtain excellent barrel plating results on brass shoe eyelets, plating them 1 hour at 12 V. and approximately 6 amps. per sq. ft. The deposits are bright and hard, yet capable of distortion without peeling. On steel eyelets, however, we notice that the deposits have a tendency to flake when distorted, after plating from the same bath for 2 hours. Is it proper to use the solution for both metals, or do you think the cleaning is at fault? We would also like to know why the steel requires twice as long as the brass for plating? C. V. D.

Answer: Your trouble with flaking, etc. on the steel eyelets is no doubt due to the heavier deposit on them. There is no reason why you should double the length of plating time because of the change in base metal, as long as you want to have the same deposit thickness on both. Heavy nickel deposits will not stand much deformation, as they are quite hard in nature, and the heavier the deposit becomes the more pronounced will be the cracking when distorted. Both metals can be plated in the same bath, but you may have to use a different cleaning technique for the steel than you do for the brass eyelets. As you did not state your cleaning cycle, it would be difficult to say whether or not some of your trouble isn't connected with this phase of the operation.

Making Up Silver Solutions

Question: Is there any advantage in using silver chloride for making up silver plating baths in place of silver cyanide?

A. M. W.

Answer: Using silver chloride in making up a silver solution is not advisable because it introduces chlorides as well as silver into the bath. These chlorides cause corrosion of the tank and subsequent contamination of the solution with iron and may result in yellowish-brown deposits being produced. Another disadvantage in the use of chloride is that twice as much sodium cyanide is required to form the double sodium-silver cyanide complex.

Hard Gold Plating

Question: The gold we plate out is too soft for the amount of handling it gets. We would appreciate any formulas for plating 24K gold that would stand a maximum amount of handling.

J. K.

Answer: Pure gold deposits (24 carat) reflect the inherent qualities of metallic gold, which is a rather soft metal. To increase the hardness of gold electrodeposits, lower carat alloy deposits are used. These alloy deposits contain copper or nickel, are harder, and have considerably more wear resistance than pure 24K gold. Several formulas for gold alloy plating are given in the GUIDEBOOK and DIRECTORY. The names of firms who can supply additional information is also being sent to you.

Nickel Plating with Insoluble Anodes

Question: Can you give us information on the possibility of nickel plating using insoluble anodes?

J. C. H.

Answer: Nickel plating with insoluble anodes has been done to a limited extent. The primary problem to be overcome is the rather rapid change in bath composition, which would require close control. The material used for "insoluble anodes" would have to be carefully chosen, as baths containing chlorides (nickel chloride, ammonium chloride, etc.) would, under the electrolyzing conditions, attack most materials, even platinum. For this reason carbon anodes are the only practical material. These too have disadvantages, as they disintegrate and introduce particles into the bath. Bagging these would be necessary.

For baths containing no chlorides, lead anodes would be suitable. Further information is available from the Bureau of Mines Report of Investigation # 3483 (1939).

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Wheel Speeds for Polishing and Buffing

In the table below, recommended surface speeds for polishing and buffing various metals are given. Polishing speeds are those generally used for wheels or belts set with glue for hand polishing. Slightly higher speeds are possible with cement-bonded abrasives, or with automatic polishing equipment.

SURFACE FEET PER MINUTE

Operation	Carbon & Low Alloy Steels	Stainless Steel	Brass	Nickel	Aluminum & Zinc	Chromium Plate
Polishing	7-8000	8- 9000	7000	8000	6000	
Cutting Down	9000	9-10000	7-9000	7-9000	6-8000	
Color Buffing	7-9000	8- 9000	6-8000	6-8000	6-7000	7-8000

To find the surface speed of a polishing wheel or buff, the following table can be used. On machines not having speed indicators, the spindle speed can be checked with a contact type speed indicator or a Strobotac.

SURFACE SPEED OF WHEEL IN FEET PER MINUTE

R. P. M. at Arbor or Spindle	DIAMETERS OF WHEELS IN INCHES											R. P. M. at Arbor or Spindle
	4″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″	
800	837	1256	1675	2094	2513	2932	3351	3770	4189	4608	5026	800
900	942	1413	1885	2356	2827	3298	3770	4241	4712	5184	5655	900
1000	1047	1570	2094	2618	3141	3665	4189	4712	5236	5760	6283	1000
1100	1152	1727	2304	2880	3455	4031	4608	5183	5760	6336	6911	1100
1200	1256	1884	2513	3142	3769	4398	5027	5655	6283	6912	7540	1200
1300	1361	2042	2723	3404	4084	4764	5446	6126	6807	7488	8168	1300
1400	1466	2199	2932	3666	4398	5131	5865	6597	7330	8064	8796	1400
1500	1571	2356	3142	3927	4712	5497	6284	7069	7854	8640	9425	1500
1600	1675	2513	3351	4189	5026	5864	6703	7540	8378	9216	10053	1600
1700	1780	2670	3560	4451	5340	6230	7121	8011	8901	9792	10681	1700
1800	1885	2827	3770	4713	5654	6597	7540	8482	9425	10368	11310	1800
1900	1989	2984	3979	4975	5969	6963	7959	8954	9948	10944	11938	1900
2000	2094	3141	4189	5236	6283	7330	8378	9425	10472	11520	12566	2000
2100	2199	3298	4398	5498	6597	7696	8797	9896	10996	12096	13194	2100
2200	2304	3455	4608	5760	6911	8063	9215	10367	11519	12672	13822	2200
2300	2408	3612	4817	6022	7225	8429	9634	10839	12043	13248	14451	2300
2400	2513	3770	5027	6284	7540	8796	10053	11310	12566	13824	15079	2400
2500	2618	3927	5236	6545	7854	9162	10471	11781	13090	14400	15708	2500
2600	2722	4084	5445	6807	8168	9529	10890	12253	13613	14976	16336	2600
2700	2827	4241	5655	7069	8482	9895	11309	12724	14136	15552	16964	2700
2800	2932	4398	5864	7331	8796	10262	11728	13196	14660	16128	17592	2800
2900	3037	4555	6074	7592	9110	10629	12147	13667	15184	16704	18221	2900
3000	3141	4712	6283	7854	9425	10996	12566	14137	15708	17280	18850	3000
3200	3351	5026	6702	8378	10053	11729	13404	15079	16755	18431	20107	3200
3400	3560	5340	7121	8901	10681	12462	14242	16022	17802	19583	21363	3400
3600	3769	5654	7539	9425	11309	13193	15079	16964	18850	20735	22619	3600
3800	3979	5969	7958	9948	11938	13927	15917	17907	19897	21887	23876	3800
4000	4188	6283	8377	10472	12566	14661	16755	18850	20944	23039	25132	4000

For machines having a single speed only, the surface speed of the polishing wheel or buff may be varied by using combinations of pulley sizes. To determine the size of pulleys needed for various speeds, with the motor speed and wheel diameter known, the following formula may be used:

$$\text{Required Dia. of Motor Pulley} = \frac{\text{Surface Speed Desired} \times \text{Dia. of Driven Pulley}}{\text{RPM of Motor}}$$

Example: For a surface speed of 5000 rpm., with a motor speed of 1750 rpm. and a driven pulley 1½ inches in diameter, the motor pulley size required would be

$$5000 \times 1\tfrac{1}{2} \div 1750 = 4.28 \text{ inches.}$$

The nearest pulley to this size would be either 4 or 4½ inches in diameter. (Pulley diameters on V-belt pulleys are always measured at the bottom of the V.)

Patents

Electrolytic Tin Plate

U. S. Patent 2,434,290. *Harry S. Schutte, assignor to Carnegie-Illinois Steel Corp.*

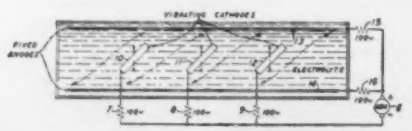
Electrolytic tin plate having manufacturing marks on the surface of its steel base that are conspicuous against a shiny background and with its tin coating too thin to hide said marks, said tin plate being characterized by having the surface of its steel base roughened to a mat finish ranging in grain size from a maximum insufficient to cause the production of flat light-reflecting surfaces of sufficient areas to be visible to the unaided normal eye, to a minimum sufficient to cause enough scattering of reflected light to at least materially reduce the visibility of said marks, said mat finish in all cases obscuring said marks.

An electrolytic tin plate making method comprising the steps of producing shiny-finished cold-reduced steel strip of from 38 to 21 gage with marks conspicuous on its shiny surface, annealing said strip, tempering said annealed strip in a temper rolling mill having rolls roughened to a mat finish imparting a similar mat finish to said strip, said mat finish having a grain size ranging from a maximum insufficient to cause the production of flat light-reflecting surfaces of sufficient areas to be visible to the unaided normal eye, to a minimum sufficient to cause enough scattering of reflected light to at least materially reduce the visibility of said marks, said mat finish in all cases obscuring said marks, and electroplating tin onto said tempered steel strip to a thickness ranging from .00001 to .0001 of an inch.

Method of Plating Contact Surfaces of Magnetic Reeds

U. S. Patent 2,438,897. *John T. L. Brown, assignor to Bell Telephone Laboratories, Inc.*

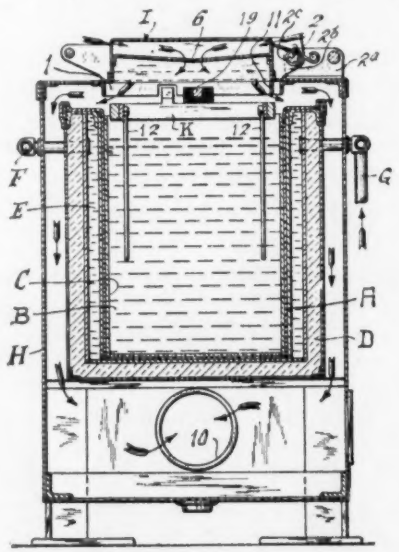
In the manufacture of electrical apparatus consisting of glass sealed magnetic reed contact elements, the step of plating the contact surfaces of the reeds with a noble metal by placing each of a plurality of said reeds in an individual cathode circuit including an individual fixed resistance of approximately 100 ohms and completing said circuits in parallel through a noble metal plating electrolyte to a common anode to render the current in each said individual cathode circuit substantially uniform and equal to the current in each other of said parallel circuits regardless of variations in the individual resistance of the reeds.



Enclosed Electroplating Tank

U. S. Patent 2,439,491. *Charles Schiffl.*

An electroplating tank comprising a container for an electrolyte having an open top, a casing completely enclosing

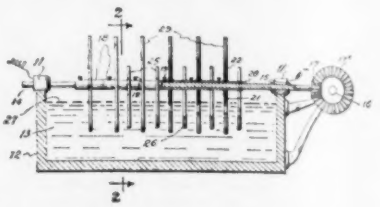


said container and having a top wall provided with an opening above said container for access to the latter, a removable cover for said opening having top, side and end walls and a partition beneath said top wall of the cover formed with portions extending from the side walls that converge downwardly toward and meet above the open top of the container so that moisture rising from the electrolyte in said container will impinge on said converging portions, perforations in said converging portions closely adjacent the meeting line of said portions and perforations in the side walls of said cover above said partition, and means for drawing air through said perforations and transversely of the open top of said container for cooling said converging portions to cause condensation of moisture thereon and to withdraw some of the gases that rise from said electrolyte.

Apparatus for Electroplating Rings and Discs

U. S. Patent 2,438,885. *Henderson M. Bell, assignor to Chromium Corp. of America.*

An apparatus for plating annular articles which comprises in combina-



tion a plating tank holding an electrolytic plating bath, open bearings mounted on top of opposite walls of said tank, a work-holding cathode shaft journaled in said bearings, means for rotating said shaft; said bearings and said rotating means permitting the lifting of the shaft and the work bodily out of said bearings and said tank; a plurality of work-holding hubs having elongated sleeve portions adapted to be slipped on said shaft in abutting relationship in such manner that the length of the sleeve portions determines the spacing of said articles and the shaft is protected from the plating bath, three annularly spaced spokes mounted on and radiating from each of said hubs, two of said spokes being of fixed and equal length while the third is adjustable in length, said spokes having outer ends adapted to engage the inner rims of said annular articles in order to support and hold said articles concentrically and in predetermined positions about said hubs, a plurality of anodes mounted in the tank inbetween and in spaced relationship with said articles, a shoulder on said shaft forming a stop against which said hubs are abutted to determine their spacing from said anodes, and means for supplying plating current to said shaft and said anodes.

Coating on Metals

U. S. Patent 2,434,525. *Robert M. Thomas, Charles W. Ostrander, and Walter H. Kaelin, assignors to Rheem Mfg. Co.*

The method of producing an integral corrosion-resistant coating on zinc, cadmium or copper comprising subjecting the same to an aqueous dip essentially consisting of water, a water soluble chromium compound selected from the group consisting of chromic

ALUMINUM CLEANING MADE EASY

When you use Cowles Aluminum Cleaners you reduce your cleaning problems to a minimum.

Cowles A E Cleaner is a low pH cleaner with synthetic emulsifying and wetting agents designed for both still tank and electrocleaning of aluminum. It is fast-acting and free rinsing. It is economical to use because of its long life in solution. Cowles A E Cleaner is non-etching—will not attack the aluminum at high concentrations and high temperatures.

Cowles 352 Cleaner is especially designed for pressure type and other standard type washing machines. It incorporates all of the desirable characteristics of A E Cleaner but *will not foam.*

COWLES TECHNICAL SERVICE ON REQUEST

Your Cowles Technical Man is especially qualified to render service on all cleaning problems on aluminum and its alloys.

PROMPT SHIPMENTS FROM LOCAL STOCKS

The Cowles Detergent Company

Metal Cleaner Department

7016 EUCLID AVENUE **CLEVELAND 3, OHIO**

acid and salts thereof and an alkali metal thiosulfate in smaller amount than said chromium compound.

Finger Cot

U. S. Patent 2,434,317. *George L. Gross.*

An open ended tubular finger cot having a seamless double ply open end and double ply seamless sides, said double ply open end being characterized by resistance to fraying and raveling when rubbed and abraded in grinding, buffing and polished operations.

Method of and Means for Providing Cathodic Protection of Metallic Structures

U. S. Patent 2,435,973. *Arthur B. MacTaggart and George J. Thomson assignors to Rusta Restor Corp.*

The method of protecting a corrodible metallic structure against deterioration in contact with an aqueous electrolyte, which comprises connecting such structure at spaced points with plural negative poles of a source of direct electric current alternately supplied in low frequency to said poles, while maintaining a positive pole of such source in electrical connection with such structure.

Abrasive Wheel Casing

U. S. Patent 2,436,621. *Alton E. Tobey.*

A casing comprising an outer split band having inward and outward overlapping ends, means permanently connecting said ends together, an inner split band located within the outer band, means permanently connecting one end of said inner band to said inward overlapping end of said outer band adjacent said connecting means first named and at a point spaced inwardly from said end of said inner band whereby said end projects beyond the inward end of said outer band and due to said overlap, in spaced relation to the first band to form a channel, and the other end of said inner band being slidable in said channel.

Solvent for Degreasing Iron and Aluminum

U. S. Patent 2,435,312. *Walter Klabunde, assignor to E. I. du Pont de Nemours & Co.*

A solvent for degreasing iron and aluminum comprising trichlorethylene containing, as stabilizer against condensation reactions of trichlorethylene catalyzed by said metals, 0.02 to 1% by weight of diisobutylene.

Method of Regenerating Anodizing Baths

U. S. Patent 2,436,940. *Joseph Schulein.*

A method of regenerating a chromic acid anodizing solution having a pH value less than 3 and containing undissociated aluminum dichromate, which comprises adding an alkaline agent of the class consisting of sodium hydroxide, potassium hydroxide, lime, calcium hydroxide and calcium carbonate to said solution to increase its pH value to not less than 3 and form an aluminum hydroxide precipitate, separating said precipitate from said solution, and thereafter removing the metal ions of said alaline agent to adjust the pH value of said solution to less than 1.3.

A method of controlling the pH value of a chromic acid bath for anodizing aluminum-containing articles, comprising segregating a portion of said bath, adding lime to said portion to adjust the pH value of said portion to at least 3.0 and precipitate an aluminum compound in said portion, filtering said portion to remove the insoluble aluminum compound, adding sulfuric acid to the filtrate to adjust its pH value to between about 0.6 and 1.3, removing any precipitate formed thereby and adding the filtrate to the remainder of said bath.

Process for Preparing Potassium Stannate

U. S. Patent 2,436,974. *Hartmut W. Richter, assignor to Metal & Thermit Corp.*

The process of preparing potassium stannate which comprises adding to an impure tin compound an amount of caustic potash in the presence of a sufficient amount of water to form at least a colloidal solution of the tin values, the amounts of caustic potash and water being sufficient at least to produce such solution but insufficient to completely combine with the tin values present to form potassium stannate, the impurities present in the tin compound being left undissolved in the colloidal solution and physically separable therefrom, separating said impurities from the solution, adding a sufficient further amount of caustic potash such as to completely combine with the tin values to form potassium stannate.

Method of Protecting the Surface of Articles Formed from a Magnesium Alloy

U. S. Patent 2,438,740. *Charles William Clark and Warren Arthur Sheaffer, assignors to Canadian Copper Refiners, Ltd.*

The method of forming a selenium-containing protective coating on an article, which is composed principally at least of magnesium, comprising the steps of cleaning the surfaces of the article to be coated, preparing an immersing solution in the following proportions: dissolving 20 grams of selenium dioxide in water, separately dissolving 10 grams of potassium permanganate in water, mixing the solutions thus made, diluting the mixed solutions to a total volume of 1 liter, and filtering off any precipitate formed to leave the filtrate as an immersing solution, and immersing the article in a solution as thus prepared while the solution is at a temperature of about 90° C. to its boiling point and for a period of about 5 to 15 minutes.

Metalworking and Stripping-Plating Process

U. S. Patent 2,436,244. *Harry L. Benner and Robert R. Bair, assignors to E. I. du Pont de Nemours & Co.*

In a process for selective case hardening, the steps comprising applying a coating of copper to a portion of a steel article, subjecting the coated article to a carburizing treatment, and thereafter stripping the copper coating from said article by anodic treatment in an electrolyte comprising essentially dissolved alkali metal copper cyanide in a concentration equivalent to 2 to 20 ounces per gallon of copper cyanide (CuCN), free alkali metal cyanide equivalent to 0.5 to 4 ounces per gallon of sodium cyanide, and phosphate ions equivalent to 2 to 16 ounces per gallon of $Na_3PO_412H_2O$, while maintaining said electrolyte at a pH of 10.9 to 13.0 and at a temperature of about 75 to 85° C. and maintaining the voltage of the electric current at about 1 to 2.5 volts.

(*Continued on page* 94)

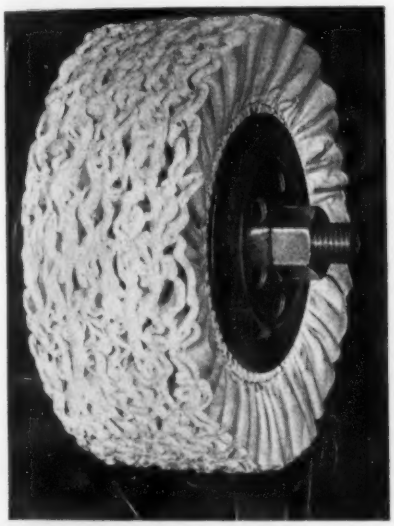
New Methods, Materials and Equipment for the Metal Finishing Industries

Recent Developments

Contact Wheel for Belt Polishing

Jackson Buff Corp., Dept. MF, Long Island City, N. Y.

A new Airway Ventilated Contact Wheel for abrasive belt polishing has been announced by the above firm. This new contact wheel has been de-



signed for contour or flat work on stainless or carbon steel stampings, aluminum, brass, die-castings and forgings. The wheel offers maximum resilience, yielding readily to pressure, and springing back into shape quickly for the next pass, it is claimed.

The ventilation feature of these wheels makes them ideal for all plants where high speed contour polishing of metals, plastics or wood is important.

The Airway Ventilated Contact Wheels are available in 6" to 16" diameters in standard sections of ½" face. Width of wheel face can be changed to suit each job.

A folder describing in greater detail the advantages of their contact wheels is available to all interested persons.

Polishing Wheel Cement

Wallace A. Erickson & Co., Dept. MF, 842 N. Wells St., Chicago, Ill.

Extraordinary flexibility, combined with exceptional adhesive strength, are claimed for a new polishing wheel cement called *Wheel King*.

Wheel King has been sold on a limited basis for a period of several months. Reports from users show much better polishing results and far less tendency to drag or glaze than with hide glue, it is said. On a wide range of polishing jobs *Wheel King* is producing from 25 to 60% more pieces per setup than with hide glue on the same work. The reports claim highly

successful results with 240 and all coarser grains, including use on grease wheels and abrasive belts.

It is manufactured in one form only for use with all grain sizes to 240. It is shipped ready-to-use and is applied cold. To a large extent the same consistency is used for all grain sizes.

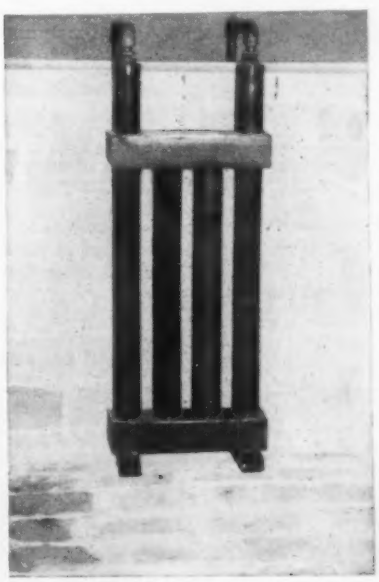
Experience has shown that the great advantages of *Wheel King* become more fully apparent after users become familiar with its application and use. To encourage experimental use by all polishers to the point of familiarity, the manufacturer has arranged an On-Approval Introductory Offer covering 5 gallons at the nominal price of $5.00. Full credit is issued upon return of any portion of the 5 gallons in case the user does not find *Wheel King* advantageous for his work.

Heating Devices for Corrosive Chemical Solutions

Heil Process Equipment Corp., Dept. MF, 12901 Elwood Ave., Cleveland 11, O.

New designs with greater efficiency have been added to the line of heating devices manufactured by the above firm. Now the Nocordal heating transfer equipment includes a new rugged grid exchanger as well as the tube immersion units, electric tank heaters, shell and tube exchangers and steam jets.

The new grid exchanger is outstanding in its rugged compact design, versatility of application and its efficient adaptation of heat transfer principles, it is claimed. Notice its design for completely submerged installation, the vertical radiating surface, the provision



Luster-on* makes your zinc plate shine — and stay that way

Luster-on bright dip gives zinc a long-lasting bright finish, proofed against rust and white corrosion.

Luster-on bright dip on zinc doesn't affect spot welding or soldering.

Luster-on bright dip on zinc increases a product's service expectancy and user satisfaction.

Luster-on bright dip on zinc is a cold, quick, non-electrolytic process, speeds production.

Luster-on bright dip on zinc eliminates finger prints and handling marks on assembly.

Luster-on bright dip on zinc maintains the "sales appeal" of articles stored or handled.

Luster-on bright dip on zinc costs only half as much as cadmium and is superior to it.

Luster-on bright dip on zinc is the quick, economical finish for radio, electrical, machine, automotive and ventilation parts, builders' hardware, hand tools, fasteners, sporting goods and toys.

We want to prove these statements to you. We want to show you *why* Luster-on is first in its field, *how* it's first in results. Send us a sample for free processing. We'll give it the Luster-on treatment, and tell you the full story on how it's done. No obligation, of course.

83

*Reg. U.S. Patent Office

THE Chemical CORPORATION
54 Waltham Ave., Springfield 9, Mass.

THE CHEMICAL CORPORATION
54 Waltham Ave., Springfield, Mass.

Please send me full particulars about Luster-on* bright dip for zinc-plated surfaces. I am (am not) sending sample for free dip. No obligation, of course.

Name _____

Firm _____

Address _____

Metal Finishing, July

for free flow of convection currents around the smooth non-clogging surfaces.

These heating units were developed to meet numerous requests for suitable heating and cooling devices to serve under the very corrosive action of most acids, alkalies, solvents and salt solution. The following advantages are claimed:

Resistance to most chemicals,—no contamination.

Excellent heat transfer,—better than most metals.

Low thermal expansion,—resistance to thermal shock.

A complete line of redesigned heating units including the rugged grid exchanger, tube immersion units, electric tank heaters, steam jets and the shell and tube exchangers are built by the Heil Process Equipment Corp.

Powdered Hand Cleaner

Rossaul Company, 170 *Fifth Avenue, Dept. MF, New York* 10, *N. Y.*

A new borax based powdered hand cleaner. Removes grease, dirt, ink, vegetable dyes, chromic acid stains, walnut stains and many other difficult contaminations. Restores "slip" to hands that have cracked under solvent cleaning. Highly abrasive, yet gentle enough to be used on the body. Effectively removes some of the causes of dermatitis. Completely soluble in water —will not clog drains. Manufactured under a special process that permits its sale at a price considerably under the competitive market.

Packaged in 100 and 300 pound drums. Four ounce samples sent on request written on company letter head only.

New Water-Soluble Cutting Oil

Beacon Rust-Roofing Co., Dept. MF. 19 *W.* 31st *St., New York, N. Y.*

From a formula extensively used in Germany before the war, a new cutting oil which is claimed to eliminate the need of further rust prevention treatment for tools, materials and machinery is now being marketed in this country.

For most metals it is used one part Ferox cutting oil to 49 parts clear water. For use on cast iron and malleable iron, one part cutting oil is used

with 33 parts of clear water. For operations which call for threading or polishing, it is used one part to 35 parts clear water.

Ferox is said to differ from the general run of soluble cutting oils because the solution remains completely clear at all times. No milky emulsion is formed because soaps and alkalies are not used to keep the oil in suspension, and a homogeneous combination is achieved when Ferox cutting oil is mixed with water.

Multiple Tumbling Barrels

Daniels Plating Barrel & Supply Co., Dept. MF, 129 Oliver St., Newark, N. J.

Heretofore, firms desiring multiple tumbling barrel units have majorly designed and manufactured their own.

The Daniels Plating Barrel and Supply Company have designed and manufactured a new and improved unit to meet a wide variety of requirements. The entire unit, consisting of two to ten tumbling barrels, is chain driven by a worm gear reduction motor. Each wood cylinder (or any other type cylinder) is separately controlled and independent from the others by a means of a positive engaging clutch, which is engaged and disengaged by means of an easily accessible handle. The space under each cylinder is partitioned to prevent work from spilling into adjoining trays when cylinders are being emptied. In the partitioned space, two screened trays, one on top of the other, slide on tracks under each cylinder. The top tray will screen tumbling mediums from work, and the bottom screen will retain the mediums. Beneath all the trays and cylinders, a drain pan, with one or two outlets, is supported on the framework legs.

The rigid framework is of double welded steel construction. The entire unit is designed to reduce installation costs and to afford ease in handling multiplicities of parts for tumbling.

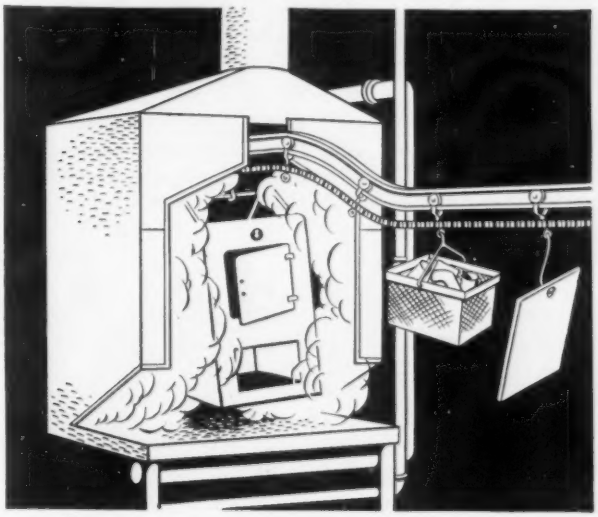
New Germicide for Equipment Sanitation

Willson Products, Inc., Dept. MF, Reading, Pa.

A newcomer to the field of personal protective items is an especially powerful germicide announced by the above firm.

The germicide is offered to industry for sterilizing personal safety equipment and protecting workers from con-

PARTS CLEAN
SOLUTION CLEAR



THANKS TO WYANDOTTE MK-50 SOLVENT DETERGENT

WYANDOTTE MK-50 is without an equal as an emulsion cleaner. It may be used with or without alkalies in pressure-type metal parts washing machines—also as an additive to drawing, cutting, grinding and slushing oils and compounds to facilitate their removal after metal processing.

As a solvent detergent, MK-50 is used primarily in spray-type washing machines for cleaning parts between machining operations and prior to inspection, painting, etc.

It rinses quickly and thoroughly and leaves no harmful salts on the metal surface. It is a neutral product and *does* leave a very light film on the metal which serves as a temporary rust inhibitor. This film helps bond any paint, enamel or lacquer finish.

MK-50 helps keep the washing solution clear, too. In the metal parts washing machine, it will throw out the absorbed oils and grease, so that they may be held on the surface of the sump or overflow section of the washer. This leaves the main body of the solution relatively clear.

Your Wyandotte Representative will be glad to tell you more about Wyandotte MK-50 and other Wyandotte Metal Cleaners. He's only a telephone call away.

Wyandotte
REG. U. S. PAT. OFF.

WYANDOTTE CHEMICALS CORPORATION
WYANDOTTE, MICHIGAN • SERVICE REPRESENTATIVES IN 88 CITIES

DIVCO
No Warping
No Buckling
No Twisting
with DIVCO
71-Point LEAD ANODES
Warped Anodes are Wasteful
The reinforced ribbed construction of Divco 71-Point Anodes prevents warping. The anodes stay where you put them in relation to the work. Uneven deposit or burning and excessive current loss due to warped anodes are avoided. Uniform deposit is assured on piece after piece.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71
71 throwing edges—plus 15.5 square inches of surface per inch of length—give Divco Anodes unequaled throwing power. They speed chrome plating, produce a more uniform deposit—and save time, material and current.
Yet pound for pound, Divco 71-Point Anodes cost no more. Equip a tank and Compare Results.
Order from your Plating Supply Jobber or direct.
Merely specify size of bus bar and distance from top of bus bar to bottom of anode.
Avoid Substitutes
Look for "DIVCO" beneath the hook or count the 71 edges
"A Good Name Carries Weight"
Division Lead Co.
828 W. Kinzie St. Chicago 22, Ill.
Other DIVCO PRODUCTS
LEAD
Sheet—Pipe—Wire—Foil
Fabrication & Lead Burning
Lead Lined Tanks
Lead Steam or Cooling Coils
Conforming Anodes

tamination through the use of such devices. It is a non-corrosive, non-staining solution, which is practically odorless. Though about 25 times more powerful than carbolic acid, the germicide is non-poisonous and non-irritating to the skin, it is claimed. In addition to its powerful germ-killing action, the solution acts as a deodorant and fungicide.

It may be used as a spray, swabbing solution, or immersion solution for gas masks, goggles, welder's masks, respirators, safety shoes, boots or any washable apparel.

The germicide is effective in hot or cold water in the recommended concentration of 2 teaspoonfuls to a quart of water, but users are cautioned not to mix the solution with soap.

Carboy Truck

Palmer-Shile Co., Dept. MF, 16035 *Fullerton Ave., Detroit, Mich.*

A safe carboy truck for handling chemicals, acids, etc., has just been developed by this firm.

This truck is designed to speed up the handling of dangerous chemicals or any liquid generally encased in a carboy.

Just roll the truck up against the carboy and drop the handy gripping-yoke over the top, then pull back on truck handles and loading becomes automatic. Hardened steel studs on the truck frame hold load in place. To unload simply tip truck forward and release gripping yoke. This truck will save a lot of dangerous, heavy lifting, avoid costly accidents, and speed up an otherwise slow and cumbersome task.

All steel welded construction. Well

shaped, curved handles assure secure gripping. Overall width only 20", permitting easy passage through narrow doorways and crowded aisles. Overall length 48". Two 8" by 2" roller bearing wheels afford smooth wheeling of even the heaviest load. Rubber, pneumatic or metal wheels are available depending on individual requirements. Capacity 500 lbs. Weight 75 lbs.

Rinse Tank Agitator and Siphon Breaker

The Beaton and Cadwell Mfg. Co., Dept. MF, New Britain, Conn.

A new device for use on water rinse tanks to prevent back siphoning, and to increase stirring through aeration has been announced by the above firm. Mounted on the water inlet line, this device permits a great saving in the amount of water required for thorough rinsing, inasmuch as the air that is introduced with the inlet water promotes rapid agitation and stirring with much less water being used. Very reasonably priced, the device is said to pay for itself in a very short time in the saving in rinse water. There are no parts to wear out or corrode, and the device is easily installed near the valve in a matter of several minutes.

Pressure Pump for Spray Polishing

J. J. Siefen Co., Dept. MF, 5657 *Lauderdale Ave., Detroit, Mich.*

The above firm announces an addition to the "Siefen System" for the spraying of buffing and polishing com-

pounds to revolving wheels to increase the efficiency of the spray system.

This air operated positive pressure pump furnishes compound to the spray guns, circulates it, and returns it to the drum, thus assuring sufficient compound at all times to each gun as well as a means of mixing the material in the drum.

Broadway Rubber Expands Surface Treating Facilities

The Acme-Fisher Division, Broadway Rubber, Corp., Dept. MF, 529 *E. Broadway, Louisville* 2, *Ky.*

The above firm has expanded its specialized surface application facilities for treating racks and hangers, anodes, pickling tanks, drums, pails, dippers, pipe and fittings, air agitation systems, tank bottom protective grids

and screens, coils and ventilation equipment.

To meet specific requirements, the company first analyzes the problem and then recommends the type of surface treating necessary for a satisfactory solution. Their recommendations may call for Laybond Rubber, Hard Rubber, Koroseal, Neoprene, Phenolics, Ceramics, etc., or may indicate a type of treating not yet developed. If a solution is possible, the company can treat the surface either at its own or the customers plant.

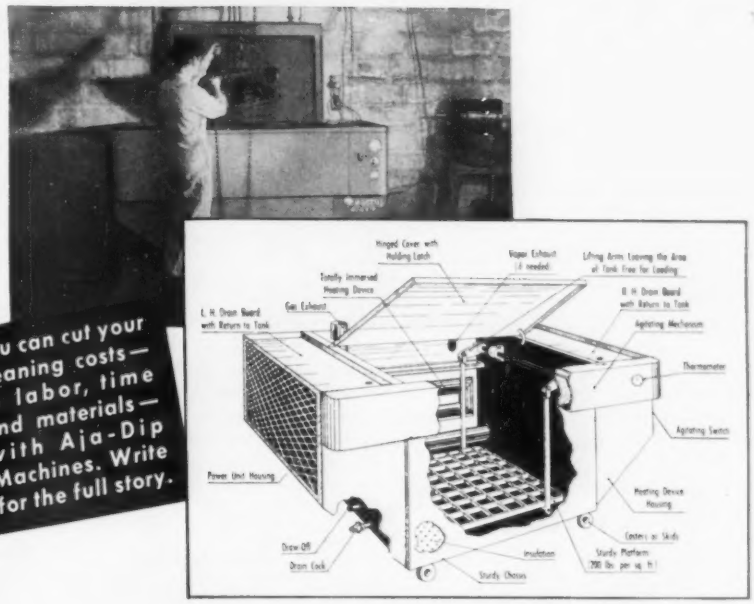
Low Velocity Dust Collector

Torit Mfg. Co., Dept. MF, St. Paul 2, *Minn.*

Where the utmost in dust control efficiency is desired, this new dust collector will meet every requirement. It is designed expressly to meet the standards of certain codes in the matter of filter velocity.

The Torit No. 68 Dust Collector has sufficient filter cloth area to provide a 4 to 1 filter velocity (4 c.f.m. through each square foot of filter cloth). And they will not bunch to-

Agitation SPEEDS CLEANING of Metal Parts


You can cut your cleaning costs—in labor, time and materials—with Aja-Dip Machines. Write for the full story.
Hinged Cover with Holding Latch
Vapor Exhaust (if needed)
Lifting Arm Leaving the Area of Tank Free for Loading
Totally Immersed Heating Device
Gas Exhaust
L. H. Drain Board with Return to Tank
R. H. Drain Board with Return to Tank
Agitating Mechanism
Thermometer
Agitating Switch
Power Unit Housing
Heating Device Housing
Casters or Skids
Drain Off
Drain Cock
Insulation
Sturdy Platform 200 lbs. per sq. ft.
Sturdy Chassis

MAGNUS AJA-DIP MACHINES Vastly Improve Cleaning Quality as Well as Speed!

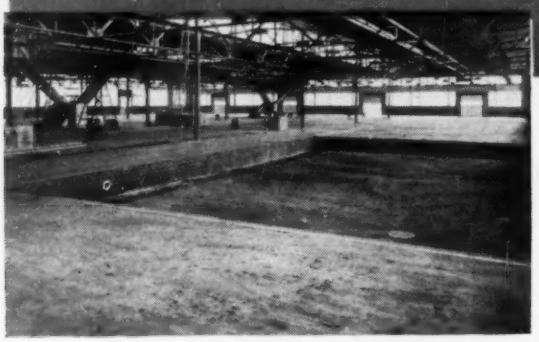
THE dynamic agitation provided by the Magnus Aja-Dip Machine so greatly increases cleaning speed, and so definitely improves cleaning quality that in many plants these batch type machines are used for the production cleaning jobs which ordinarily would be entrusted to conveyorized spray-type cleaning machines.

Agitating the *work* up and down *in* the cleaning solution adds penetrating mechanical cleaning action to the chemical effects of the solution. And these sturdy, powerful machines are made in a range of capacities to handle from 75 to 2,200 lbs. of basketted or racked parts.

MAGNUS CHEMICAL COMPANY
11 South Ave., Garwood, N. J.
In Canada—Magnus Chemicals, Ltd., 4040 Rue Masson, Montreal 36
Service representatives in principal cities

IN METAL CLEANING IT'S Magnus
CLEANERS • EQUIPMENT • METHODS

Corrosion Attack...
need no longer put brakes on *YOUR PRODUCTION!*



This Atlas Floor in plating room of nationally famous radio manufacturer, has served eight years without "down time".

Tanks, floors and other equipment subject to acids, alkalis, corrosive salts and solvents can be made proof against — not merely "resistant to" these elements.

Atlas acid-proof equipment serves in plants ranging from small plating works to large steel and chemical works — handling every type of industrially used corrosive.

Size is no handicap. Atlas builds platers' small portable tanks to be shipped out by rail or truck — and pickling tanks up to hundreds of feet in length . . . also floors that defy corrosion.

Atlas Materials include acid-proof brick, cements, jointing materials, plastic linings and protective coatings. Atlas furnishes design and, if desired, installation also. Our engineers will be glad to study your acid-proofing problem and to make recommendations, plans and estimates — without obligation. Contact our nearest branch.

Write our Mertztown Office for Bulletin T7-D.

THE *Atlas Mineral* *Products Company of Penna.*

THE ATLAS MINERAL PRODUCTS CO. OF TEXAS INC., Box 252, Houston 1, Tex.

MERTZTOWN — PENNSYLVANIA

*BERKELEY 2, Calif., 605 Addison St.
DALLAS 5, Tex., 3921 Purdue St.
*DENVER 2, Colo., 1921 Blake St.
*HONOLULU 2, Hawaii, U. S. A.
OMAHA, Neb., 423 South 38th Ave.
*LOS ANGELES 12, Cal., 1725 Central Ave.
*SEATTLE 4, Wash., 1252 First Avenue, S.
*Stock carried at these points
*ATLANTA 3, Ga., 452 Spring St., N. W.
*CHICAGO 1, Ill., 333 No. Michigan Ave.
*DETROIT 2, Mich., 2970 W. Grand Blvd.
NEW YORK 16, N. Y., 280 Madison Ave.
PITTSBURGH 27, Pa., 4921 Plymouth Rd
PHILADELPHIA, Pa., 355 Fairview Rd. Springfield, Pa.
ST. LOUIS 8, Mo., 4485 Olive St.

IN CANADA: Atlas Products are manufactured by H. L. BLACHFORD, Limited, 977 Aqueduct Street, Montreal 3, P. Q., 86 Bloor St. W., Toronto, Ont.

gether under pressure, as each filter is filled with copper wire mesh, to prevent collapsing.

The filters are installed in a new manner, assuring a dust-proof seal.

The cabinet measures 29½" wide, 40" high, 26" front to back. It is equipped with a ½ H.P., 3450 RPM motor and 7 11/16" x 1½" fan (the same power unit as used in the Torit No. 64 Dust Collector). The maximum inlet area is that of one 3" inlet.

The low air volume-filter area ratio insures maintenance of the original operating characteristics over a longer period of time than is possible where filter cloth is called upon to handle a large air volume.

Water-Displacing Solvents

Metal-Clean Solvent Corp., Dept. MF, 1935 N. Paulina St., Chicago, Ill.

Two new water displacing products, known respectively as Metal-Clean No. 11 and Metal-Clean No. 12 are announced by the above firm. Designed to produce a positive moisture-free surface on all metals (ferrous and nonferrous), these new liquids lift water droplets instantaneously and leave a protective film on the work. Water thus displaced drops to the bottom of the tank where it can be drawn off periodically. Fingerprints are neutralized and water stains prevented, it is claimed.

Metal-Clean No. 11 is used as a cold dip. Through its application, the usual drying operation, with its attendant oxidation or hydration of the metal surface, is eliminated, and faces are protected by a dry film which is neutral and harmless for further finishing or for plating, according to the company.

Metal-Clean No. 12 is a water displacing type of rust preventive especially designed for work which is to be held for storage.

Under alternating conditions of high and low temperatures and humidity, Metal-Clean No. 12 passes 30-day condensation tests, successfully inhibiting rust, and also passes the standard 30-day humidity cabinet test and the 30-hour salt spray test, according to the manufacturer's claims. Work held for indoor storage is protected for six months or longer.

The material is applied by either the cold dip, brush, or spray operation. Action is instantaneous. A monomolecular film forms on the metal and the displaced water sinks to the bottom of the tank. The protective film on the metal parts can be easily removed with ordinary petroleum naphthas.

Prevention of Heat Fatigue

Benson Laboratories, Dept. MF, Bessemer Bldg., Pittsburgh, Pa.

A new product for the prevention of heat cramps and heat exhaustion has just been announced by this firm.

This new product differs from other heat cramps preventives such as salt tablets in two signicant respects: First, they contain not only Sodium Chloride (Common Salt) but also two other body salts in approximately the same proportion as they are lost in perspiration, it is claimed. They also contain Dextrose to provide a quick energy restorer. Second, these heat fatigue drops are made in special butterscotch candy form which is refreshing and pleasing to the taste.

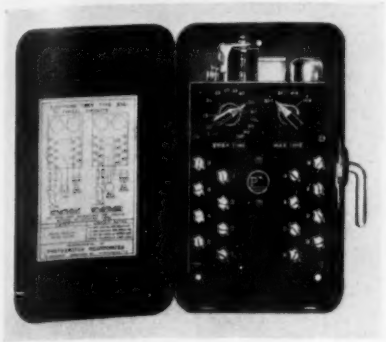
Benson heat fatigue drops are individually wrapped in convenient, easy-to-use form. The average employee will use about six pieces per day and the cost is low, averaging about 2¼ cents per employee per day so that the cost for the entire 60 or 80 working days of hot weather is small.

Samples are available on request to interested executives.

Electronic Interval Timer

Photoswitch, Inc., Dept. MF, 77 Broadway, Cambridge 42, Mass.

Electronic Timer Series 30 is de-



signed for machinery and process control. It has a range of from .03 seconds to four minutes. It is recommended for the control of hydraulic presses, chemical feeders, spot welders, grinders, conveyors, drilling machines, photographic printers, and similar equipment.

This timer provides for all basic types of timing through simple terminal panel connections, and may be wired to provide interval timing, delayed action, automatic repeat, and programming as well as many variations of these.

SPECIFICATIONS:

Supply: 115/230 Volts, 50-60 Cycles
Output: Two single-pole, double-throw switches
Relay Contact Rating: 10 amps, 115 V AC (main output) 1 amp, 115 V AC (auxiliary)
Accuracy: Within 2%
Ambient Temperature: 32° to 150° F
Ambient Relative Humidity: 20% to 95%
Net Weight: 8 pounds

New "Twin Barrel Lifter"

Merrill Bros., 56-02 Arnold Ave., Maspeth, N. Y., Dept. MF.

It is claimed by the above firm that at last the metal barrel has become sufficiently important to devote enough time and thought to an arrangement by which it can be hoisted straight up, rather than by the old make-shift method of lifting it at an angle by gripping and raising from one side.

It brings the common metal barrel into its own as a substantial conveying

FOR { Grease and Oil? / Paint and Enamel? / Insoluble Dirt? / Electrolytic? } Yes!

There's a Specialized DETREX Cleaning Agent for EVERY Cleaning Job!

There's a Detrex solvent or cleaning compound for *every* cleaning application—a *specialized* cleaning agent, scientifically designed for maximum speed and economy. These include:

DEGREASING SOLVENTS for . . .

- *Both ferrous and non-ferrous metals, and adverse operating conditions*, where maximum stability is called for—PERM-A-CLOR, the most highly stabilized of all trichlorethylene solvents.
- *Average applications*—TRIAD (identical to Perm-A-Clor in cleaning power).

ALKALI AND EMULSION CLEANERS for . . .

- *Aluminum* parts and *painted surfaces.*
- *Brass, aluminum* and *white metal* parts.
- *Heavy-duty* cleaning of *iron and steel* and their alloys.
- Cleaning and neutralizing prior to *vitreous enameling.*
- *Electrolytic cleaning* especially for plating.
- *Heavy-duty stripping* of pigmented oil paints, synthetics, and baked enamels.
- *Removing all kinds of oils and insoluble dirt*, without attack on surface or coating.

. . . **AND** there are Detrex degreasers, parts washers and dip tanks to most efficiently use these specialized compounds, assuring 100% soil-removal with minimum time and cost.

A Detrex field representative can help you on *every* industrial cleaning application.

Degreasing Machines and Safety Solvents • Metal Parts Washers • Alkali and Emulsion Cleaners and Strippers • Processing Equipment • Spray Booth Compounds

SA 4-48

DETREX Corporation
DETROIT 32, MICHIGAN

Reduce your overhead ... effectively control fumes

Niehaus Fume Separator

● Niehaus Fume Separators will reduce your overhead two ways . . . overhead expenses and space-consuming overhead ductwork. By water absorption and centrifugal separation, it will effectively control the fumes from your cleaning and plating solutions.

The complete unit is located alongside your tank . . . no expensive blowers or long ducts are required. No air is discharged outside.

For complete specifications and information on how the Niehaus Fume Separator eliminates costly equipment, reduces installation costs, and sells for less. Write for illustrated folder.

INDUSTRIAL ELECTROPLATING COMPANY, INC.
219 West Vermont Street, Indianapolis 4, Indiana

and storage media, being a most economical and convenient means.

This duel clamp is the adaptation of the regular Volz Clamp to a form adaptable to the barrel, being a device consisting of a cross arm of the width of the standard barrel, with a Volz Clamp attached to both ends of the arm.

The center of the cross bar is provided with a ring through which the hook of the hoist or other lifting media is attached.

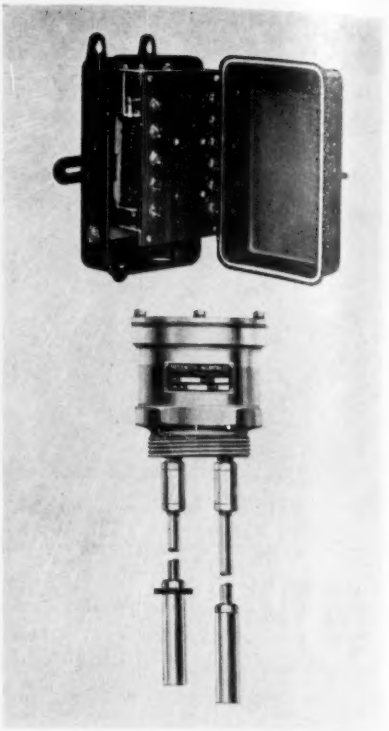
The clamps can be instantaneously attached and detached to and from the barrel. The heavier the load, the tighter is the grip of the Volz Clamp, according to the manufacturer. They are sold through leading hardware jobbers and mill supply houses.

General Purpose Level Control

Photoswitch Inc., Dept. MF, 77 Broadway, Cambridge 42, Mass.

Photoswitch Type 10CB1 introduces completely maintenance-free level control to the chemical processing industry. This control consists of an electric relay operating from a probe circuit through a transformer and a rectifier. Only stainless steel probe rods are located in the liquid itself.

Type 10CB1 will control the level of practically all electrically conductive liquids. The probe circuit may be set at several different sensitivities. As a result it will discriminate between a liquid and its foam. It is not affected by the saturated vapor above a liquid in a closed tank, permitting positive



control of acid in batch processing, it is claimed.

The liquid to be controlled makes or breaks contact with the probe and transmits to the control a minute electrical current at low voltage. This current controls a power circuit which operates a relay to actuate signals, valves, or pumps.

Metal Cleaners

Calgon, Inc., Dept. MF, Pittsburgh, Pa.

Two new metal cleaners, said to be effective individually or in combination for cleaning a wide variety of metals and alloys, are being announced by the above firm following a long period of laboratory and field research and testing.

The announcement marks official entry of this manufacturer into the metal cleaner field, with products specifically developed for this purpose, although the company's water-conditioning materials are used extensively in industrial cleaning work.

Calgon Metal Cleaner No. 21 is described as a dry granular alkaline detergent for spray-cleaning in metal-washing machines. In addition, it has claimed to be effective when used in combination with the new Calgon emulsion cleaner, for immersion cleaning in dip tanks and for heavy-duty spray cleaning.

Although designed primarily for cleaning of steel products or parts, is said to be well-suited for a wide variety of other metals and alloys. It effectively spray-cleans aluminum, for example, without etching its surface, chemical engineers of the company report; in long immersion or dip-type cleaning of aluminum a slight etching may occur. It is said to be excellent as a pre-cleaner when the metal surface is to be phosphate-coated.

Calgon emulsion cleaner is described as a white, creamy emulsion of an organic solvent in a relatively small amount of water. It readily disperses when added to the cleaning bath. It is recommended for use in combined solution with Calgon Metal Cleaner No. 21 for immersion cleaning or especially difficult spray-cleaning. This mixture or combination of the two cleaners is said to provide the advantages of an alkaline cleaner with those of an organic solvent.

Calgon emulsion cleaner, when used alone or in combination with an alkaline cleaner, is said to be easily rinsed from the metal surface with either hot or cold water, leaving no solvent or other film. This is said to distinguish this cleaner from most other emulsion cleaners, and is particularly important when the cleaning is to be followed by electroplating.

Heavy Duty Metal Cleaner

Klem Chemical Works, 14401 *Lanson Ave., Dept. MF, Dearborn, Mich.*

A new, heavy duty still and soak tank cleaner of the faster acting type has been announced by the above firm. It is recommended for all types of heavy duty cleaning of ferrous metals. Though developed chiefly as a general purpose cleaner, No. 159 has proven itself valuable as a cleaner before galvanizing and porcelain enameling as well as a soak cleaner before plating, it is claimed.

No. 159 is said to do an outstanding job of removing carbon smut, and has had an enthusiastic reception from engine rebuilders.

This is claimed to be an exceptionally economical cleaner to use, for it can be used in low concentrations without impairing its efficiency. Cleaning procedure for soak or still tank requires a concentration of only six ounces of cleaner to a gallon of water. Concentrations can be increased or decreased to four or eight ounces to the gallon depending upon the speed required for the cleaning job to be done. Water temperatures should be held as near boiling as possible. Rinsing after cleaning is simple and frees the surface of all impurities, leaving it thoroughly clean for the next operation, according to the maker.

COATING-TIME CUT IN HALF!

...with the New, 100%-Solids Unichrome Coating 218

FIVE HUNDRED RACKS were coated with 218 in half the time usually spent with solvent types—that's the report from a big user of Unichrome Coating 218.

How are such huge savings possible? Because fewer coats are needed. You use only one main coat of 218 over a prime and "tie" coat—the entire job taking about 2 hours.

And not only is this coating *quicker* to apply, it also *lasts longer*. For Unichrome Coating 218 cures to a smooth, elastic, thick jacket that resists all plating and cleaning baths, and won't chip or tear. It will pay you learn more about it. Write today.

(Ask us for the name of a local applicator who will coat your racks with 218 if you don't have a baking oven.)

SEND FOR THIS BULLETIN, which explains how to save time and money in insulating your racks.

UNICHROME

Trade Mark Reg. U.S. Pat. Off.

RACK COATINGS—Products of
UNITED CHROMIUM, INCORPORATED • 51 E. 42nd St., New York 17, N.Y.
Detroit 7, Mich. • Waterbury 90, Conn. • Chicago 4, Ill. • Dayton 2, Ohio • Los Angeles 13, Cal.

Chrome-Faced Piston Ring

Wilkening Manufacturing Co., Dept. MF, Philadelphia, Pa.

According to an announcement of this firm, its new Pedrick chrome-faced piston ring has an efficient life that is two to four times longer than other rings.

Long wear results from the high anti-friction and lubricant-retaining characteristics of the chrome face, in both heavy-duty, high-temperature service and where abrasive dust is present. It is claimed also that the chrome plating reduces cylinder wear and the wear of all the other rings in the installation.

Dedrick states that its new chrome-faced ring has three years of development and testing back of it. To make full use of the wearability of the chrome a new metal was developed for the ring. It is a special alloy, centrifugally cast, then heat-treated to produce a dense, uniform structure which is tough and resilient, with very high tensile strength—the metal characteristics most needed for successful service as a top-groove piston ring. This new alloy is said to be safe from break-

Filter All Plating Solutions Faster, More Completely in

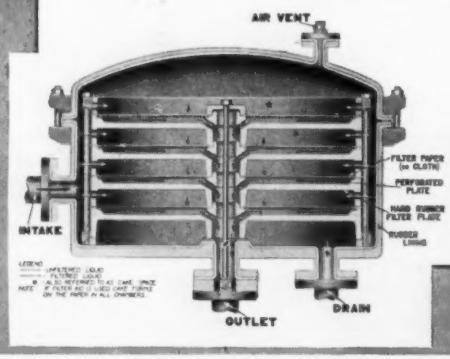
SPARKLER *Horizontal Plate* FILTERS

Because the filter cake is held horizontally, it is absolutely stable to the end of each filtering cycle. And cycles are longer because the cake retains its porosity longer. That is why the "horizontal principle," as embodied in Sparkler filters, gives you more efficient, low cost, operation. Sparkler filters are pressure-tight and leak-proof, designed for intermittent or continuous operation.

4 Plating Solution Types

1. Rubber-lined for bright nickel
2. Stainless steel for acids
3. All Iron for alkaline solutions
4. All Steel (with Stainless Pump) for chromium

SPARKLER MANUFACTURING CO.
Mundelein, Illinois



Made in Capacities
60 to 10,000 G.P.H.

See your supplier or Write for details

Our Engineering Service is available for any specialized problems.

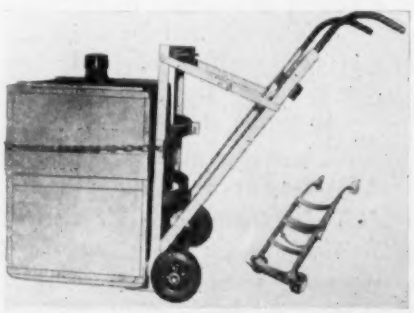
age even under very heavy loads because it is not subject to hydrogen-embrittlement as are ordinary metals when chrome-plated.

Safety Hand Truck

General Scientific Equipment Co., Dept MF, 1327 Bankers Security Bldg., Philadelphia 7, Pa.

A light-weight, sturdy hand truck, combining many safety features is available from the above firm.

Of riveted, welded and bolted construction, with tubular handles, and 6" aluminum acid-resistant wheels or rubber tires, this safety truck has two carrying positions which adapt it to a variety of portage jobs. In the open position the truck can be used to safely move carboys, acetylene tanks, barrels, packages and other items in a vertical position to avoid spilling the contents. In the closed position the truck can be used as a hand truck to transport



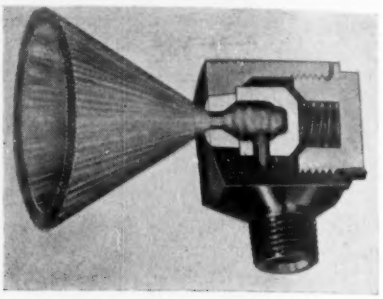
boxes, barrels and similar items in the conventional manner.

According to the manufacturer, the truck is designed to give maximum leverage on the handles and to carry the load on the wheels. The hand truck can be easily converted from one position to the other and is firmly secure in either position. A chain is provided to hold items being transported.

Tungsten Carbide Nozzle for Spraying Abrasive Liquids

Spraying Systems Co., 4021 W. Lake St., Chicago, Ill., Dept. MF.

A new Whirljet spray nozzle, fundamentally new in design, is now being produced by the above firm. This nozzle is a true Whirljet type, producing



a hollow cone spray pattern. Under tests this nozzle has demonstrated amazing resistance to wear, it is claimed. For example, under one application the life of the nozzle was approximately 150 times longer than that of standard nozzles. In this new Whirljet, a vortex chamber as well as an orifice insert are made of tungsten carbide as shown in the illustration. Inlet to the vortex chamber is drilled on a line tangent to the circumference to provide correct vortex action of the liquid in producing an open hollow cone spray. Nozzle body and retainer cap are made of 18-8 stainless steel. These new Whirljet nozzles are now available in six standard sizes.

Reinforced Asbestos Gloves

Industrial Glove Co., Dept. MF, Danville, Ill.

An improved leather reinforced Asbestos Gauntlet has been designed by this firm. Reference to the accompanying photograph shows that the usual seam on the palm, or working surface, where thumb and palm are joined, has been eliminated. There is no seam now to rip or burn out at the very important part of the glove.

The new construction feature applied to this type of glove provides a continuous leather wearing surface over the asbestos palm, fingers *and* thumb. The seam that makes the thumb now is on the top edge of that digit, well out of the wearing zone.

Business Items

Pennsalt Transfers Special Chemicals Salesman

John W. Beaver has been named sales representative for the Special Chemicals Division of the *Pennsylvania Salt Manufacturing Co.* in the newly-created Maryland, Washington, D. C. and Virginia district, it was announced recently by *Joseph J. Duffy, Jr.*, Manager of Sales.

Mr. Beaver, formerly sales representative in the Wisconsin territory, joined Pennsalt on February 1, 1946, after nearly four years, service in the United States Army Air Force.

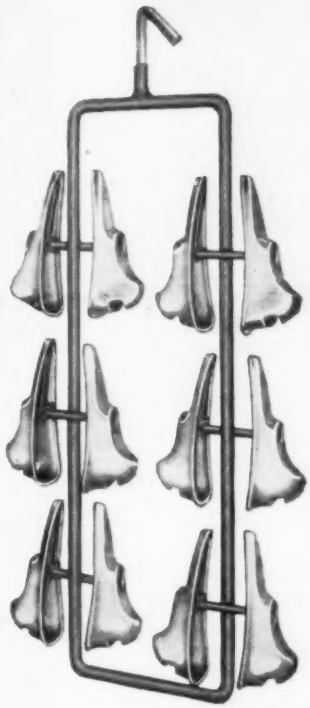
John H. Matthews Elected Canadian Raybestos Director

John H. Matthews, vice president and director of *Raybestos-Manhattan, Inc.*, was elected to the Board of Directors of the Canadian Raybestos Company, Ltd., at the Annual Meeting held at Peterborough, Ontario, Canada, on May 20.

Wyandotte Holds Regional Educational Conferences

Salesmen of the *J. B. Ford Division* of *Wyandotte Chemicals Corp.* recently attended three-day educational conferences in the seven regional headquarters of the organization — New York, Atlanta, Cincinnati, Indianapolis, Chicago, Kansas City and Montreal.

BUNATOL



No. 1000

INSULATION

For racks and fixtures used in electro plating, anodizing, electro polishing, phosphate coating and electro forming.

SAVES LABOR

Has extra fluidity. Dips freely. Handles fast, without delays or trouble. A rack can be completely insulated in two hours.

SAVES TIME

No evaporation — no shrinkage — no loss. Short oven bake converts to continuous solid coating that has no effect on, but excellent resistance to all plating solutions and cleaners.

SAVES MONEY

Racks last longer because a single dip gives an extra heavy, thick, extremely tough, long life protective coating, which far outwears ordinary types of insulation—and at less cost.

APPLICATORS:

If you prefer to send your racks out for insulating write for name and address of nearest applicator using No. 1000 Insulation. That means you get the best at the right price.

100% Solids

No liquid to evaporate. Does not become thick or lumpy. Always ready to use. Not inflammable.

Write for details and prices

NELSON J. QUINN COMPANY

TOLEDO 7, OHIO

Both sound and slide films were used in the conferences which were attended by a rotating team of home office sales, advertising, and technical service executives.

One session of the conference was devoted to cleaning before metal finishing with a special meeting for the Wyandotte Industrial Department representatives who were present.

A written examination was given at each of the seven conferences in the service and technical information and methods used by Wyandotte representatives. The three-day educational sessions stressed the demonstration and tests which will be of practical value to Wyandotte customers.

Seated, left to right: G. T. Robinson, Northwestern Region Supervisor and Chicago Manager; C. J. Rohrbacher, Manager Milwaukee; Carter B. Robinson, Vice President In Charge of Sales J. B. Ford Division; A. C. Weimer, Manager Minneapolis; Harry Rightmire, Manager Maintenance Cleaning Department and Ass't Manager Food and Beverage.

Standing, left to right: Lee Minor, Earl Soop, Don Anderson, Technical Service Department; Tom Blair, Ass't Director of Advertising; W. C. Fronrath, Advertising Department; E. S. Schmeling, Ass't Manager Industrial Department.

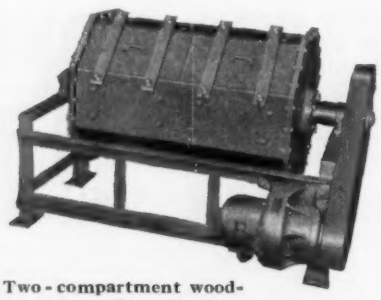
General Ceramics Appoints D. D. Foster Company

The General Ceramics and Steatite Corp., Keasbey, N. J. recently an-

A TUMBLING BARREL FOR EVERY PURPOSE

Yes . . . Henderson can supply you with tumbling equipment in a variety of sizes, shapes and materials for practically every tumbling requirement. Nearly three quarters of a century in designing and manufacturing tumbling barrels for the GRINDING, BURNISHING, POLISHING and CLEANING of metal stampings, balls, bearing races, forgings, small castings, screw machine products, jewelry, wire forms and small metal parts. Tilting type barrels of Steel, Wood or Alloy Metal . . . Horizontal type barrels of Cast Iron or Cast Steel. Wood or rubber lined in all Models. Also special barrels for plastics.

#5A Motor Driven Tilting Oblique Tumbling Barrel.



Two-compartment wood-lined Burnishing Barrel.

If your requirements call for faster production and finer quality at lower cost or if you require Tumbling Barrels of special design, our Development and Engineering Service will be glad to make recommendations.

Write for further information.

Since 1880 - Designers and Builders of Tumbling Barrel Equipment

THE HENDERSON BROS. COMPANY
135 SOUTH LEONARD ST. WATERBURY 85, CONN.

nounced the appointment of *D. D. Foster Co.* of Pittsburgh as their representatives for western Pennsylvania, Ohio, and West Virginia.

The D. D. Foster Company, who are sales engineers in the field of equipment for the petroleum-chemical industry, are now prepared to offer equipment fabricated of chemical porcelain, chemical stoneware, and impervious graphite, to the processing plants in their territory.

Pesco Announces New Warehouse Facilities

Pesco Plating Equipment Corp. and *Metal Finishing Mfg. Corp.* are pleased to announce the removal of their warehouses and factories to their new plant located at 75-77 *Wythe Avenue* or 87 *North 11th St., Brooklyn, New York.* From this centrally located point with a floor space capacity of more than 18,000 square feet, shipments, stockpiling, production facilities as well as service in general will be greatly enhanced.

In addition, Pesco Plating Equipment Corp. will maintain their usual showrooms and sales offices at 182 *Grand Street, New York* 13, *New York.*

Sternal Joins Jackson Buff Corp.

L. S. Sternal has joined the *Jackson Buff Corp., Long Island City, New York* as sales manager. His duties will include building a national sales force to adequately service the demand for the company's products. Mr. Sternal graduated from Carleton College, Minnesota. He later worked for General Electric Company in Schenectady and Bridgeport. Prior to the war, he was a sales engineer for *Minnesota Mining and Manufacturing Company, New York Branch.* After serving three years in the Navy as an Officer on the Staff of a Destroyer Squadron Commander, he rejoined Minnesota Mining as Methods Engineer. Mr.

L. S. Sternal

Sternal gained wide experience developing new usages and applications for the polishing industry.

Holtmeier Appointed Representative for Standard Electrical Tool

W. J. Holtmeier, 71 *W.* 23rd *Street, New York* 10, *N. Y.,* has been appointed Eastern District Manager for *The Standard Electrical Tool Co., Cincinnati, Ohio.* He will handle the States of Connecticut, Northern New Jersey, Rhode Island, Metropolitan New York, Eastern Pennsylvania and that strip of New York State that extends from New York City north including Peekskill, Beacon, Poughkeepsie, Albany, Troy and Schenectady.

Lupo Organizes Barrel Finishing Laboratories

Joseph Lupo resigned as Vice-President of *Lupomatic Industries, Inc.* and is now devoting his time to organizing research and service laboratories in several large industrial centers in the United States and Canada. The labora-

tories will operate under the name of *Lupo Research Laboratories*. Mr. Lupo has spent thirty-five years developing, manufacturing, and designing tumbling machinery and compounds used by the jewelry, plastic, and metal finishing industries. The laboratories will have all facilities to run through any parts submitted and also to do production job testing.

With the most modern facilities, Mr. Lupo will expedite his plans for research work to ultimately develop faster processing tumbling equipment, more economical tumbling compounds, and easier ways to handle tumbling machines. The first laboratories are already in operation; one at 3636 *Park Avenue, New York City;* one at 745 *Plainfield Street, Providence, Rhode Island;* and one at 9 *North West Street, Mount Vernon, New York.*

Joseph Lupo

CHROMIC ACID

99.75% PURE

With two complete, independent plants at Jersey City and Baltimore, and over a hundred years of technical background, Mutual is the world's foremost manufacturer of Chromic Acid.

MUTUAL CHEMICAL CO. NEW YORK

OVER A CENTURY OF CHROMIUM CHEMICAL PROGRESS

Bichromate of Soda

Bichromate of Potash

MUTUAL CHEMICAL COMPANY OF AMERICA

270 MADISON AVENUE NEW YORK 16, N.Y.

Roberts Rouge and McAleer Ltd. Combine Manufacturing in Canada

The Roberts Rouge Company of Stratford, Conn. announce that *Mr. Theodore F. Onkey* has been elected President of *The McAleer Manufacturing Company, Ltd., Chatham, Ontario, Canada* in which the Roberts Rouge Co. has purchased a substantial interest.

Because of the Austerity Program and conservation of Canadian funds, many substantial Canadian accounts purchasing buffing compounds from the local firm have curtailed their purchases. By combining interests, formulae and know-how of Roberts Rouge Co., with McAleer Mfg. Co., a complete line of Roberts buffing and finishing compounds will also be produced in Canada.

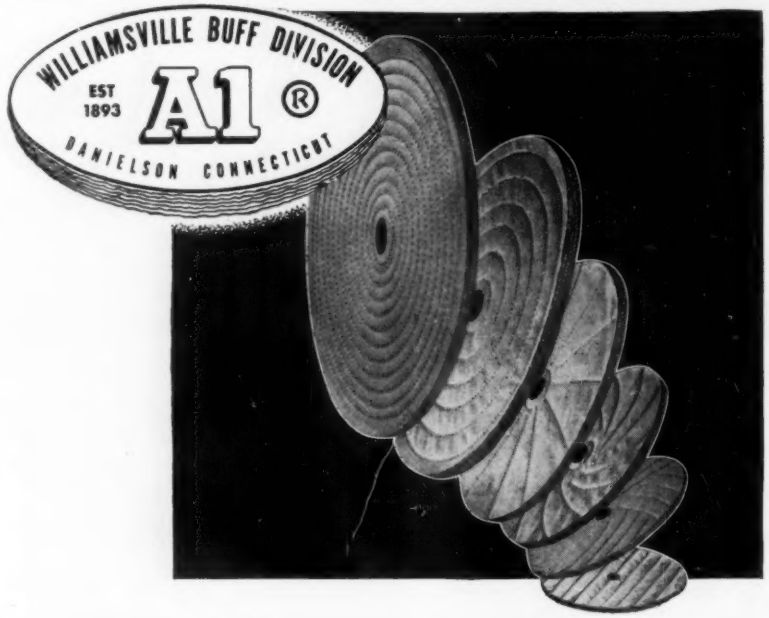
On the other hand, a complete line of polishing, rubbing and cleaning compounds for the automobile industry, and floor waxes and silver creams for household use, which comprise a major share of McAleer's production in Canada, will be manufactured for domestic consumption by Roberts Rouge Co., in Stratford. This arrangement will make Roberts Rouge Company the only buffing compound manufacturer producing a complete line for both Canada and the United States.

The McAleer Mfg. Co. Ltd., enjoys a reputation for quality products since it was established in 1931.

Mr. Onkey states that The Roberts Rouge Company has no immediate plans for further expansion of manufacturing facilities in Stratford at present, but that outlets for the many items they will eventually manufacture are being surveyed with building and expansion plans in mind. These plans will also include an increased sales force and expansion of jobber outlets.

Williamsville Buff Consolidates with the Bullard Clark Co.

Announcement has been made that the *Williamsville Buff Manufacturing Co.* has been consolidated into the *Bullard Clark Co.*, together with the other affiliated companies of the *E. H. Jacobs Mfg. Co.* The purpose of the consolidation is to give improved service to industry through increased pro-



Crack Down on Overhead with Williamsville Buffs

Are all metal finishing needs alike? Not by a long shot! That's why Williamsville buffs and wheels are job-tailored to your particular needs in coloring, cutting, and polishing. They run cool, save compounds, won't ravel, and give the kind of wear that makes cost-conscious management smile with satisfaction.

And no wonder — because Williamsville buffs are made of the highest quality sheeting, carefully cut, turned, stitched, and trimmed. To metal finishers with a weather-eye on competition we offer savings in overhead costs through better buffing. The proof? Consult us now about your requirements. Write, wire, or phone.

WILLIAMSVILLE BUFF DIVISION
The Bullard Clark Company
DANIELSON, CONNECTICUT

duction and facilities. Plans for modern equipment and increased floor space are now under way.

The Williamsville Buff Division was organized in 1898 by the Williamsville Cotton Mills of Conn. which was purchased by *W. Irving Bullard* and *Frederick A. Jacobs* in 1905. The buff business was retained by the Jacobs Company and the cotton mill was re-equipped with tire fabric machinery and sold to the Goodyear Tire and Rubber Company of Akron, Ohio. The buff division uses over one and a half million yards of sheeting per year for the manufacture of buff wheels for polishing metal, and is also a large producer of polishing wheels made of canvas and leather for pollshing heavy machinery and hardware.

Mr. Jack D. Lodge will be the General Manager of the Williamsville Buff Division, and also becomes Vice-President and Secretary of the Bullard Clark Co.

Beckman Instruments Now Factory-Serviced in Chicago

In order to facilitate the servicing of the great number of Beckman Instruments in use throughout the Eastern and Middle Eastern areas, *National Technical Laboratories*, manufacturers of Beckman Instruments, has established its own factory servicing headquarters at 9 *South Clinton Street, Chicago, Ill. George R. Kinkaid*, Mid-Western Representative for National Technical Laboratories is in charge.

The new Chicago Service and Repair Department is staffed with factory-trained specialists and features the latest equipment for servicing and repairing Beckman pH Meters, Spectrophotometers, Radiation Meters, Glass Electrodes and many other Beckman precision control instruments.

William W. Criswell Appointed by American Wheelabrator

William W. Criswell, Jr. has been appointed Sales Representative with offices in New York City for the *American Wheelabrator & Equipment Corp., Mishawaka, Ind.*

Mr. Criswell is a graduate chemical engineer from Massachusetts Institute of Technology. He formerly was associated with the Rochester and Pittsburgh Coal Co. in a development and sales engineering capacity. Prior to that time he was employed by Combustion Engineering Corp.

He is a member of the American Chemical Society, the American Society of Mechanical Engineers, the Institute of Mining and Metallurgical Engineers and is a Registered Professional Engineer in New York State.

American Buff Appoints New Representatives

The American Buff Company, 2414 South LaSalle Street, Chicago, Ill., announces the recent appointment of *Mr. H. J. Sandstrom* as Sales Representative for portions of Maine, New Hampshire, Massachusetts, Vermont, and Rhode Island.

Mr. Sandstrom, an overseas veteran of World War I, brings to his new po-

H. J. Sandstrom

Marvin W. Radom

sition a thorough business background. During World War II he was an expeditor of materials for anti-aircraft guns. Since then he has been engaged in the machine parts business.

The company also announced the appointment of *Mr. Marvin Radom* as its Detroit area representative.

Mr. Radom is a graduate of Michigan Univ., and served overseas in the last war. He has been in Service Engineering with the company for several years.

Osborn Enlarges Ad Department and Appoints Two Field Representatives

Richard R. Schultz, former expediter in the purchasing department of the *Osborn Manufacturing Company*, 5401 *Hamilton Avenue, Cleveland O.*, has been named assistant to *J. G. Gammel*, advertising and sales promotion manager of the company.

Addition of two members to its Field Sales Staff, in the Chicago and Detroit areas, has also been announced.

Robert Ruthenberg, former Second Lieutenant in the U. S. Marine Corps Reserve and graduate of Yale University with a B.E. in mechanical engineering, has joined the staff of Osborn's Chicago office. Mr. Ruthenberg has been with the company since 1946 as a sales engineer in its Cleveland headquarters office.

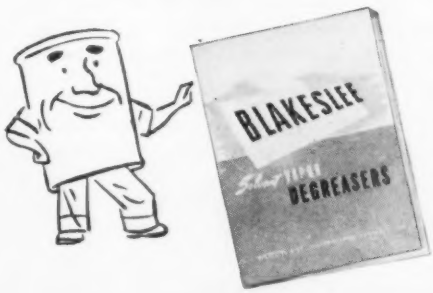
John D. Ashlin, former Flight Instructor in the U. S. Naval Air Corps, has been appointed to the sales staff of the Detroit office, under A. M. Everit, district manager. Mr. Ashlin attended the University of Detroit, was a pilot in the U. S. Naval Air Corps for four years, and served in a sales capacity with the Ferry Morse Seed Company.

CLEAN and SMOOTH

METAL PARTS COME OUT FREE OF GREASE OR CHIPS WHEN CLEANED IN A

BLAKESLEE

SOLVENT *Vapor* DEGREASER



Blakeslee Solvent Vapor Degreasers employ a patented degreasing process . . . parts made of metals and alloys chemically cleaned and dried in only a few seconds . . . no need for subsequent rinsing and drying operations. Oil and grease-free surfaces are obtained, complete oil removal from cracks, pores, seams and hidden crevices of machined parts, stampings, assemblies, etc., is assured. Masses of nested parts are thoroughly cleaned and dried throughout.

In this cleaning process, the oils and greases are dissolved by BLACOSOLV, the efficient degreasing solvent which can be used on all metals or combinations of metals. BLACOSOLV is non-inflammable and non-explosive.

Write today for FREE booklet on Degreasers and applications with Blacosolv, the all-purpose degreasing solvent.

G. S. BLAKESLEE & CO.

BLACOSOLV DEGREASERS AND SOLVENT

NIAGARA METAL PARTS WASHERS

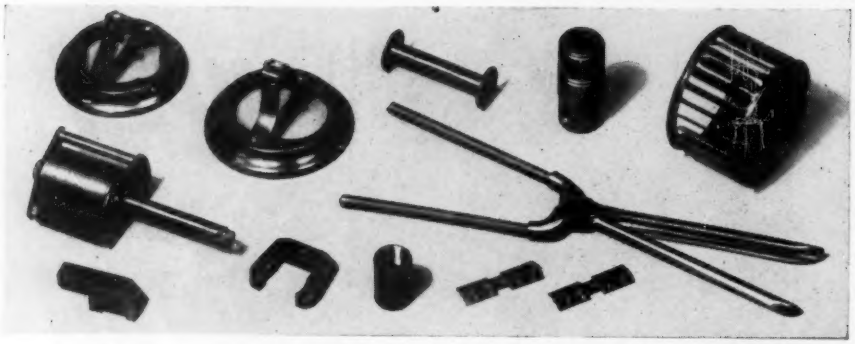
G. S. BLAKESLEE CO., CHICAGO 50, ILLINOIS
NEW YORK, N.Y. TORONTO, ONT.

Dow Names Distributor

Saran Lined Pipe Company, a newly organized firm, will act as exclusive distributors for *The Dow Chemical Company's* recently developed specialty pipe and fittings.

The pipe and fittings, lined with Saran, a Dow plastic, was developed for use where highly corrosive materials are handled in manufacturing processes. It is expected to be of special use in the fields of metal processing and plating and in chemical, pulp, paper and synthetic textile manufacturing.

S. H. Blackmore, sales manager of the Saran Lined Pipe Company whose offices are located in the Stephenson Building, Detroit, said that his firm plans to establish sales representatives and jobber outlets to handle the product throughout the country. The pipe and fittings are now in production at Dow's Midland plant and are immediately available, he said.



Du-Lite the Dependable Black Finish for Steel . . .

WHAT DU-LITE IS: DU-LITE is a black chemical finish for steel. More than a coating, Du-Lite becomes an integral part of the steel surface itself to form a chip-, peel-, crack- and blister-proof new surface. Du-Lite finish will not fracture unless the steel to which it has been wedded fractures.

WHAT DU-LITE DOES: DU-LITE produces on all steel and steel alloy parts except stainless a handsome, uniform, oil-absorptive finish that endures and that possesses rust-resistant qualities when used as recommended. You can achieve either a matte or a glossy finish. Microscopic spines and edges that are present even on highly polished surfaces are smoothed and rounded by DU-LITE.

Imposed at a non-critical temperature, DU-LITE causes no dimensional change in the parts treated and effects no change in the characteristics of the steel. Du-Lite Salts are non-poisonous, economical to use; the process is simple to operate and inexpensive to install.

For these reasons and others you can learn by writing us, DU-LITE matches or excels in every respect any other process for the chemical blacking of steel, while it remains less costly to operate than most.

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THE *Du-Lite* CHEMICAL CORPORATION

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U. S. Testing Co. Announces New Low Prices for Weather-Ometer Tests

An accepted method of testing for determining the resistance of textiles, paints, plastic materials and coated fabrics of all types to weathering, is the standard Weather-Ometer test.

The United States Testing Company, Inc., with its main laboratories at 1415 *Park Avenue, Hoboken, N. J.*, announces new low prices for Weather-Ometer tests.

The increased number of tests being conducted to determine resistance to weathering, and the importance of this method of test, has caused the testing company to reduce its Weather-Ometer fees, so that use of this important test may be still more widespread.

Du Pont Announces Increases in Prices of Chemicals

The rising cost of raw materials, production, and shipping has made necessary an increase in the prices of metallic sodium, cyanide compounds, trichloroethylene, and hydrogen and sodium peroxides, the Du Pont Company has announced.

The increases, effective July 1, are the first in the base prices of sodium, cyanide compounds and these peroxides since 1918, the company said. For instance, metallic sodium, 30 years ago, sold for $1 a pound. The new price, up one and a half cents, is 16½ cents a pound.

Sodium cyanide is up one cent a pound to 14 cents. Other cyanide compounds are increased proportionately. Trichloroethylene is up one-half cent a pound to 10½ cents. Sodium peroxide is up two cents a pound to 16 cents, and 35 per cent hydrogen peroxide is up one cent to 20½ cents.

PATENTS

(*Continued from page 78*

Preparation of Silver Foil

U. S. Patent 2,439,489. *Fritz Rosenthal, assignor to Radio Corp. of America.*

The method of making silver foil having a thickness of 0.00010 to 0.00015 of an inch, which consists in chemically depositing silver upon a polished resinous plastic sheet ranging from 0.010 to 0.020 in thickness, electrodepositing silver upon the chemically deposited layer, rinsing the sheet, and stripping the silver foil from the plastic sheet.

Method of Electrowinning Manganese

U. S. Patent 2,439,805. *Herbert R. Hanley and James H. Jacobs.*

In the method of electrowinning manganese wherein an electrolyte of manganese and ammonium sulphate is electrolyzed in a diaphragm cell wherein the current efficiency is greater than 50%, the improvement which is characterized by employing an anode of lead alloyed with one to three percent silver and of less surface area than the cathode; initially operating the cell at an anode current density above about 28 to about 58 amperes per square foot, and exceeding the cathode current density due to the difference in their areas while maintaining the current efficiency above 50%; initially depositing a protective film on the anode under said operating conditions for a period of about 24 hours and continuing said electrolysis under said operating conditions for a period of about two weeks to form a scale composed principally of oxides of manganese and lead at the anode and reduce the manganese deposited as oxide on the anode to less than 1% of the metal deposited on the cathode.

Metal Coating Metal Articles

U. S. Patent 2,441,776. *Rolfe Pottberg, administrator of U. C. Tainton, deceased, assignor to Freeport Sulphur Co.*

In a process for treating a metal article to remove oxides, scale and the like, the steps of providing a bath of a molten compound of a metal from the group consisting of the alkali and alkali earth metals and containing in solution a metal also from said group and electropositive relative to the treated metal of the article, introducing said article into said bath, maintaining said bath at a temperature below the boiling point of said treating metal and sufficiently high above the fusion point of the molten compound to maintain said supplied metal in solution in said bath at the area of contact with said article whereby to avoid a deposit of said treating metal on said article, continuing said treatment for a sufficient length of time with sufficient treating metal in solution to complete reduction of the oxides, scale and the like in the bath without accumulation of a deposit of said treating metal on the article, passing said treated metal article free of deposit of said treating metal into a contiguous bath of an inert, relatively non-coating metal, and then passing said treated metal article into a contiguous bath of a molten coating metal substantially free of said alkali metal and accumulating said coating metal in direct contact with the surface of the article.

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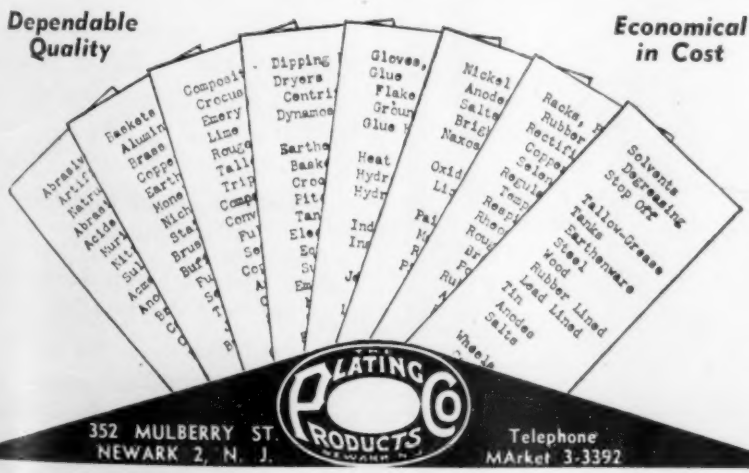

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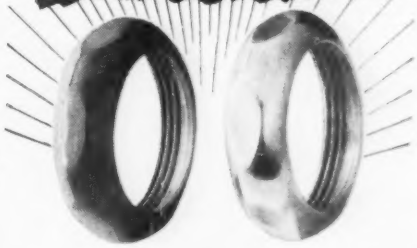

Unretouched illustration shows die cast plumbing fixture at left before Roto-Finish de-burring and finishing; at right after Roto-Finishing.

Roto-Finish eliminates the great bottleneck in modern production. Hand finishing is slow, inaccurate, and requires a large labor force. Roto-Finish processes quickly, uniformly, and without loss of tolerance, enormous quantities of intricate castings and precision parts of steel, brass, aluminum, magnesium, stainless and nickel steels. Send samples for processing. (Include finished part for guide.) No obligation.

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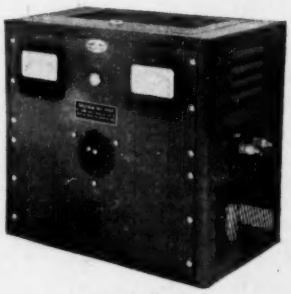

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Manufacturers' Literature

Rod Agitators for Electroplating

Belke Mfg. Co., Dept. MF, 947 N. Cicero Ave., Chicago 51, *Ill.*

A new bulletin just issued by this firm describes in detail Belke Rod Agitators for Electroplating tanks and tells how they reduce plating time, cause more uniform deposits of plating metal, and effect substantial savings in material and current. Copy of bulletin 199 mailed promptly on request.

Improved Cleaner

E. F. Houghton Co., Dept. MF, Phila., Pa.

Complete data on an emulsion cleaner—Houghto-Clean 220—is now available from this firm. This cleaner is said to be a superior replacement for either straight petroleum solvents or non-flammable solvents used for industrial cleaning. It has proved to be equally efficient for cleaning ferrous or non-ferrous metals. It also forms a stable non-foaming emulsion with water, hot or cold.

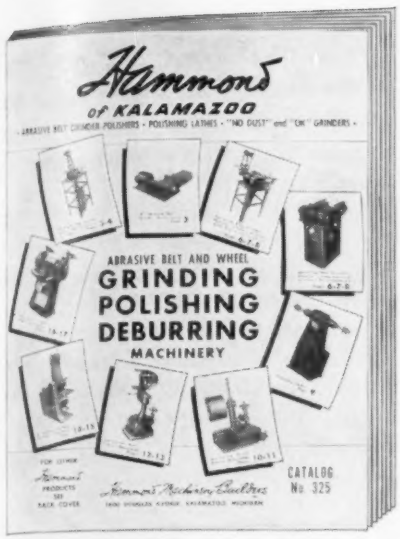
This product has many advantages over regular solvent cleaners, it is claimed, possessing higher solvency properties than do straight solvents. It readily mixes with water, is attracted to water in the spray rinse, and hence is more thoroughly removed than is a straight solvent which resists water, according to this firm. Houghto-Clean 220 contains a powerful corrosion inhibitor, is non-toxic, and does not present a fire hazard.

The various applications of this material have been laid down in a product data sheet which is available upon request.

Grinding and Polishing Machinery

Hammond Machinery Builders, Inc., Dept. GP-39, Kalamazoo 54f, *Mich.*

A new bulletin No. 325 just issued by the above firm describes their complete line of machines for polishing, grinding, and deburring. Light pol-



ishing lathes and hard-wheel grinders are also shown. Pictures of the many products that can be finished on these types of machines are included. Copies are available on request.

Alternating Current Generators

Columbia Electric Mfg. Corp., Dept. MF, 4519 Hamilton Ave. N.E., Cleveland, Ohio.

The above firm has just issued a new bulletin describing their line of alternating current generators. Sizes available range from 6¼-375 KVA in both single and three phase types. Various speeds and methods of excitation are also available. The bulletin describes in detail the various construction steps taken to insure long, trouble-free service in their equipment. Copies available upon request.

Felt Polishing Wheels and Bobs

The Bacon Felt Co., Dept. MF, Winchester, Mass.

This firm has just published a 16-page brochure describing their line of felt wheels and bobs for polishing and buffing. A description of the characteristics of felt wheels, together with specific recommendations as to their use and care are given. The bulletin also contains valuable tips on polishing and buffing operations, including setting up, balancing, etc. Special mandrels for use with felt wheels are also described, as are contoured wheels.

A copy of this booklet may be obtained by writing to the firm on your company letterhead.

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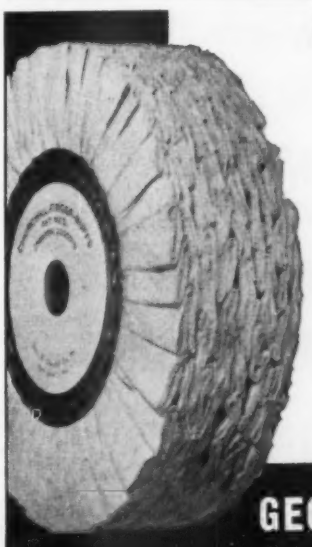

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Belt Sanders and Polishers

Curtis Mach. Corp., Dept. MF, 1939 Gibson St., Jamestown, N. Y.

A new bulletin just published by this firm illustrates their complete line of table type sanding and polishing machines. Both standard and special types are manufactured by this company. Of special interest to metal finishers is their Type 8V machine, which is equipped with its own dust collecting system and completely adjustable belt features, including provisions for belts from 1-6 inches wide and with 16 in. diameter wheels. For polishing large flat areas, these machines are available with tables up to 42 inches wide and 112 inches long. Uniform perssure over the entire area is assured through a specially designed traveling head.

Copies of this bulletin are available by writing to the above address.

Cleaning and Surface Treatment of Ferrous Metals Before Painting

Oakite Products, Inc., Dept. MF, 118 Thames St., New York 6, N. Y.

An easily-controlled prepaint procedure for cleaning and surface treatment of ferrous metals to provide improved paint adhesion is fully described in a new Service Report issued by the above firm.

Method discussed is the Oakite CrysCoat Process, in which a specially-formulated acid cleaner is applied to metal-surfaces as work is routed through a three or more stage pressure-spray washing machine. CrysCoating, the report claims, performs the following three operations *at the same time*: (1) removes light soils, grease, spinning compounds and shop dirt from work; (2) improves paint grippage by imparting on surfaces a thin, crystalline phosphate film that actually becomes part of the metal itself, and (3) retards rusting of metal surfaces between cleaning and painting operations, and localizes corrosion if painted finishes become scratched or marred during product use.

The report features an application check chart offering detailed data on CrysCoating procedures, including recommendations on specific solution concentrations, temperatures time cycles, and pH range of solutions. Readers desiring copies of this informative, 6-page Service Report may obtain them by writing to the above address.

Fabricating Semi-Precious Metals

Classifying stainless steel, nickel, Monel and Inconel as semi-precious metals, *Storts Welding Co., Inc., Meriden, Conn.*, has issued an illustrated bulletin featuring various types of plant equipment of special design fabricated in these metals. The fabrications shown include plating and rinsing tanks, processing tanks, annealing hoods, trays and baskets, piping and duct work and material handling equipment—all for service where corrosion resistance, heat resistance or both are required. The advantages and the fields of application of the semi-precious metals are noted and suggestions are given for supplying information to the fabricator when inviting estimates on special equipment for corrosion and high temperature conditions.

Rust Preventive Compounds

Freedom-Valvoline Oil Co., Dept. 26, Freedom, Pa.

Manufacturers, fabricators, and packaging engineers of ferrous and non-ferrous metallic products will be interested in a new, 14-page booklet giving general information on 23 removable rust preventive compounds. All compounds are classified and brief comparisons are made of the compounds in each group. In addition, methods of application, thicknesses and permanency of coatings, and removal are discussed.

Use of these products cover metals in storage, indoor and outdoor; parts between manufacturing operations; machinery, parts, and metal surfaces both domestic and export.

To obtain a free copy of this booklet, write the above firm.

Inco Issues New Booklet on Galvanic Corrosion

A new booklet discussing various aspects of galvanic corrosion has been issued by *The International Nickel Company*, 67 Wall St., N. Y. C. Prepared under the supervision of the company's corrosion engineering section, it is designed for the production man as well as the research engineer.

The booklet not only covers some of the factors influencing galvanic corrosion but also presents data on how galvanic effects can be minimized.

It is available without cost from the above firm.

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ELECTROPLATING MAGNESIUM AND ITS ALLOYS

(*Concluded from page 49*)

stood 60 days in high humidity at 95° F. and 85-95% relative humidity. No indication of blistering or corroded areas have been noted.

Salt spray tests on copper-nickel-chromium deposits have withstood 48-168 hours in salt spray without failure, the time of exposure before initial failure depending, of course, on the thickness of the nickel deposit. Nickel deposits in these tests ranged from 0.0005″ to 0.0015″ in thickness. See Figure II.

No failure has occurred on chromium plated parts on exterior exposure tests after three months. In this test, the thickness of the nickel was varied also from 0.0005-0.0015″.

It is interesting to note, in tests such as salt spray, when failure in the plating starts as a localized area, the corrosion does not spread rapidly between the plate and the magnesium surface. General lifting of the plate has been noted in other processes for magnesium where inferior adhesion of the plate is experienced.

Adhesion

The adhesion of the electrodeposits appears to be very good. Plated wrought products have withstood heating to the melting point of the magnesium alloy (1100-1200° F.) without a general lifting or blistering of the deposits. Cast parts will withstand heating to 450° F. and higher, depending upon the quality of the castings in respect to porosity, etc. Copper and silver plated surfaces can be readily joined by soft soldering without disrupting the adhesion. Deposits will withstand deformation by hammering and bending without failure. Heavy chromium plates have been applied to articles for wear resistance tests. Deposits of 0.0005″ can be applied without a tendency for a peeling of the deposits, even on high current density areas.

General Remarks

This new development opens up a field for the use of magnesium for many new applications where a bright tarnish resistant surface is essential, or wear resistance is required. Pilot plant tests have been made on approximately 50,000 parts and plating efficiencies have been good. The success of the process is dependent almost entirely upon the adherence and uniformity of the zinc immersion coating. Careful operation of the zinc bath, as well as assurance that the surface is clean and free of metallurgical defects, will result in electrodeposits with excellent adhesion and appearance.

Bibliography

1. *Williams*, U. S. Patent 1,562,269 (1925); *Jones*, U. S. Patent 1,594,061 (1926); *Barlow*, British Patent 259,307; *Kenega*, U. S. Patent 1,801,629; *du Pont*, British Patent 564,823.
2. Transactions Electrochemical Society. Volume 81, 213 (1942).

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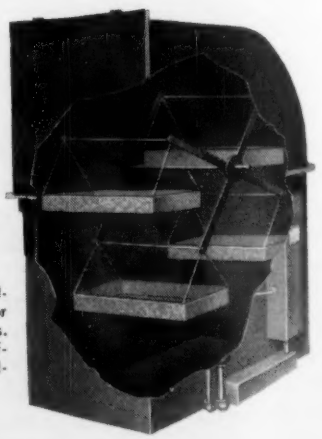

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High Vacua-Principles Production and Measurement

by Swami Jnanananda
Published by D. Van Nostrand, 250 4th Ave., N. Y. C. Price, $5.50.

The high vacuum is playing an ever more important part in industrial processes; chemical, metallurgical, and physical. An example of this is the rapid development of Cathode Sputtering methods for coating articles with metallic and non-metallic films. Evaporation of metals to form coatings is also being thoroughly investigated.

What constitutes a high vacuum, its production and measurement has been described in this book in a very technical and complete fashion. An especially thorough review of the various types of pumps for producing high vacuums is given.

S. W.

News from California

West Coast Manager for Finishing Publications

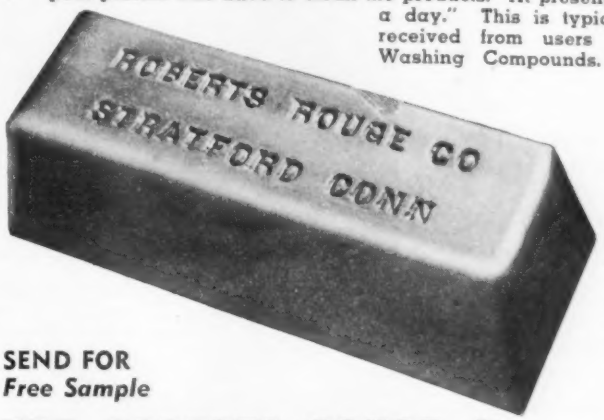
Mr. Fred A. Herr has been appointed Pacific Coast Manager for FINISHING PUBLICATIONS, INC., 11 W. 42nd St., New York 18, N. Y.

Mr. Herr is a native of St. Louis, Mo. where he received his education and early newspaper training. In 1918 he became associated with a St. Louis newspaper, and subsequently worked on papers in Dallas, Texas and Los Angeles, Calif. He has for many years been writing for national business and

Fred A. Herr

"Your Water Soluble Rouge and Tripoli are going great guns here . . . . .

. . . In my opinion, you have made a tremendous forward step in finishing compounds. This applies not only to the finishing department, but to the poor platers who have to clean the products. At present, we use one barrel a day." This is typical of many letters received from users of Roberts Quick Washing Compounds. Write for prices.



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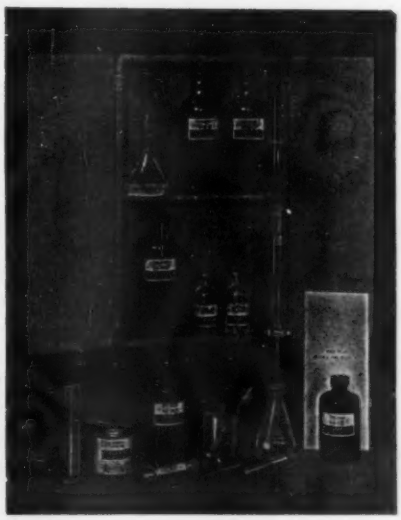

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technical magazines, and is particularly well informed on developments in the West Coast business world. He is a member of the *National Industrial Advertiser's Ass'n., American Society of Heating and Ventilating Engineers,* and the *American Electroplaters' Society,* and is very active in the California area program of the latter organization. The monthly feature "News From California" in each issue of *Metal Finishing* is contributed by Mr. Herr.

Mr. Herr's office is in the *Judson Rives Bldg., 424 S. Broadway, Los Angeles, Calif.*

Turco Products Holds National Conference

Turco Products, Inc., 6135 S. Central Ave., Los Angeles, Calif., assembled District Managers for two-day home office conference with laboratory technicians and department heads.

A review of the adaptations and application of new wetting agents and detergents to their line of specialized cleaning compounds was the principal theme of these sessions.

District Managers will in turn hold similar meetings for their field service organizations.

Pictured attending are: (Kneeling) D. S. Sprague, Aviation Department Manager, Home Office; D. A. Keating, Technical, Chicago; A. H. Massey, District Manager, Atlanta; S. B. Van Dyne, Home Office; Al Martinez, District Manager, Los Angeles; Clark Jackson, Technical, Home Office; Harry Rorick, Home Office. (Seated) T. Pew Brown, District Manager, New York; Sam Hewlings, District Manager, Philadelphia; Charles Devine, Division Manager, Chicago; S. G. Thornbury, President; W. L. Donovan, District Manager, Chicago; E. J. Broderson, District Manager, Seattle; A. K. Beard, District Manager, Cleveland; J. D. Charters, District Manager, Houston. (Standing) C. H. Williams, Assistant District Manager, Houston; J. L. Sweatt, District Manager, San Francisco; T. G. Franzreb, Technical, Philadelphia; R. L. Vignolo, Technical, Home Office; D. M. LeVasseur, Secretary, Home Office; C. E. Tronson, Credit Manager, Home Office; Dan Miller, Jobbing Manager, Home Office; Carl Hirdler, Technical, Home Office; Sidney Smith, Home Office; A. J. Bridwell, Equipment Department Manager, Home Office; F. E. Warnes, Home Office, L. H. Moulton, National Sales Director, Home Office; A. H. Gustafson, Railroad Department Manager, Home Office; D. T. Buist, Assistant National Sales Director, Home Office; A. H. Simbro, Institutions Department Manager, Home Office; George Scherrer, District Manager, Los Angeles; W. C. Sweatt, Assistant District Manager, Sacramento; G. J. Lehn, Food & Beverage Department Manager, Home Office; C. L. Kolvoord, Retail Manager, Home Office; C. H. Sykes, Jr., Assistant District Manager, Atlanta; H. B. Studebaker, Auditor, Home Office.

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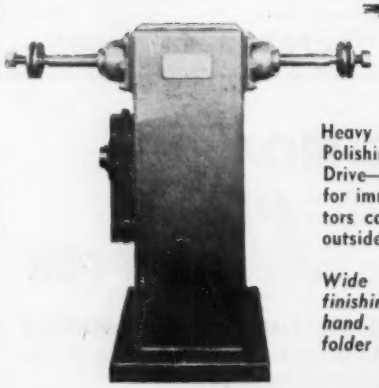

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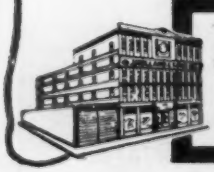
Wide selection of metal finishing equipment on hand. Write for FREE folder "P".



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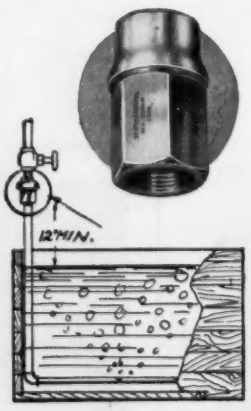
Prevents Syphonage
Agitates Water
Install over each Rinse Tank



CADWELL No. 115
Syphon Breaker
Patent No. 2241337

The admission of air with water thru supply as is possible with the CADWELL No. 115 Syphon Breaker. Agitates the water in tank. SUPPLY VALVE only needs to be opened slightly.

Order thru your Plating Supply Jobber.

Manufactured by
The Beaton & Cadwell Mfg. Co.
NEW BRITAIN, CONN.

L. D. George, recently appointed sales promotion and advertising manager for the *Vacu-Blast Co., San Mateo, Calif.*, was on a two months business trip to the middle-west and east during May and June. The firm manufactures and distributes the Vacu-Blaster, a blast cleaning device which cleans surfaces with an abrsive and picks up the resultant refuse and abrasive by vacuum.

The Cratex Manufacturing Co., San Francisco, recently introduced a compound representing a combination of rubber and abrasive grease for industrial finishing and polishing, *Jack Craven*, general manager, has announced.

The firm, established 25 years ago, is operated by *John Craven*, president, and his son Jack. They hold that there are various operations in metal finishing in which the stone and hard vitrefied wheel can go only so far, and for which the semi-firm or polishing type of wheel is more suitable. The soft rubberized grinding wheels in which the company specializes are said to fit in between the conventional type of grinding unit and the buffing wheel. Cratex wheels and points, Mr. Craven declared, are made of a tough leathery combination of rubber and abrasive grain developed specially for industrial finishing and polishing for use by mold makers, die casters, jewelers, instrument manufacturers, plastic workers, art metal workers, etc.

Russ C. Hedeen, head of the *R. C. Hedeen Co.*, San Francisco, announces the appointment of *Clifford C. Brousseau* as sales engineer for the Pacific Northwest area. The Hedeen Co., which operates a good sized warehouse and office facility at 50 Hawthorne St., serves as western representative for *Divine Brothers Co. of Utica, N. Y.*, and carries in stock in San Francisco large supplies of Divine buffs, polishing lathes, back stand idlers, dust collectors, polishing wheels, wheel cement and other Divine products. Hedeen also serves as western representative for the *Ryman Engineering Co. of Elwood, N. J.*, makers of air-operated back stands, special abrasive machines, swing and roll grinders; and for the *Curtis Machine Corp. of Jamestown, N. Y.*, manufacturers of belt sanding equipment. Hedeen operates as a jobber of metal finishing supplies in northern California and the Pacific Northwest, but distributes only to jobbers in Southern California.

James Howston is now foreman of the plating department of the *Bendix Corp., Burbank, Calif.* During the war he served in the plating department of the *Menasco Mfg. Co., Burbank*, and subsequently with *Technical Enamel Co.*

William Maxfield has been named general production manager, and *Bruce A. Weldon* head of the material department, for Aviation Maintenance Corp.

Associations and Societies

AMERICAN ELECTROPLATERS' SOCIETY

Melbourne Branch

The 33rd Regular Meeting was held at the Victorian Chamber of Manufactures on Monday 24th May, with 35 members and visitors present.

Seven new members were admitted to membership and one resignation

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Mirror Brightness
Cheaper Than Cd Brighteners

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Increase maximum allowable current density from 4 to 8 times the customary value.

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Produce mirror bright deposits at all current densities.

Eliminate silver buffing.

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We are professionally sincere; you will never hear us alibi nor hedge on our statements. Our 15 years of electrochemical experience, days upon days of research, and 10 months of actual production trial, convinces us that SIL-BRITE can give you these results.

Shipped f.o.b. our Cincinnati laboratories:

1 Gallon Cans SIL-BRITE @ $5.75/Gal.
5 Gallon Drums SIL-BRITE @ $5.50/Gal.

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P. O. Box 634 **Cincinnati, Ohio**

Improved Plating-

WITH SARCO

Controlled temperatures mean uniform, high quality plating, day in and out. You can control wash tank temperatures with the Sarco "87" at a cost of a few dollars. Most plating tanks can be controlled with the Sarco "LSI" electric control which costs much less than most methods. For special and highly accurate controls for vapor-line and heating and cooling there are a dozen different Sarco combinations. Four types of Sarco Steam Traps help reduce fuel costs.

SARCO CATALOGS

No. 1025
LSI Electric Control

No. 700
TR-40 Cooling Control

No. 650
Vapor-Line Control

No. 600
Tank Temperature Controls

No. 550
87 Trap-Control

Nos. 350 & 450
Bucket, Thermostatic and Float-Thermostatic Steam Traps

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ASK FOR THE SARCO CATALOGS ON PLATING

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SARCO SAVES STEAM
SARCO COMPANY, INC.
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was accepted. The Secretary gave members a resume of the discussion at the Committee Meeting held the same afternoon.

At the conclusion of the business session Librarian *Hugh Teague* introduced *Mr. Rod Power* of the State Film Centre who proceeded with great efficiency to put over a short programme of Technological Films. Subjects chosen included Chemical Engineering, Colloids, Atomic Power, Construction of a Railway Engine and Road Making.

Chairman Walker's vote of thanks was warmly seconded by Committeeman *Keith Leigh.*

Rochester Branch

The Rochester Branch of the A.E.S. met Thursday May 20th at Rochester Products Division of General Motors for the purpose of seeing the finishing operations at this plant.

Fifty members were shown through the plant and all were impressed by its cleanliness, efficiency and modernness. After the tour of inspection we were given a large room for our meeting.

Mr. Wagner gave the treasurers report on our April Regional Meeting. We wish to thank our suppliers for their hospitality, and the Seneca Hotel for the manner in which the affair was handled.

The members gave a vote of thanks to *President Flint* and the members of his committee and especially to *Mr. John Adams* who, as head of the entertainment committee, did such a grand job providing the floor show and orchestra.

A letter from *Mr. K. Huston* was read, praising the way we put over the Regional Meeting. We are grateful to *Messrs. Huston, Pinner, Foulke, and Nankervis* for their cooperation in presenting such fine papers.

A letter from *Mr. A. Logozzo* was read announcing that we won the membership contest for 1947-48 with 31.7% increase in members. *Mr. S. Gartland* expressed his and the members appreciation for the spirit of cooperation and the enthusiasm of the officers which made the award possible. We intend to do our best to repeat this record next year.

The members extend their sympathy to *Mrs. R. H. Walker* and family upon the death of *Mr. R. H. Walker*, Mt. Morris, N. Y., a member of the Rochester Branch A.E.S.

Four more men were elected to membership.

Delegates to the convention were appointed: *Frank Tindale, Walter Swanton, and Charles Hendershott.* Alternates were *James Weaver, William Tucker, and John Adams.*

Los Angeles Branch

Following a practice established in 1947, Los Angeles Branch of the *American Electro-Platers' Society* held its June 9 meeting in the plant of the *L. H. Butcher Company, Los Angeles,* as guests of the management.

News of the tasty dinner and the fine spirit of hospitality with which the LHB organization entertained the branch in 1947 appeared to have circulated around Southern California, resulting in an overflow attendance of about 200 members and guests.

Quite appropriately, the chairman of the evening was affable *Frank*

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Urea and Phenol Plastic Compounds
Brine
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WIRE OR PHONE COLLECT.

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Bunker, an LHB sales engineer, who is the incumbent branch president. *Mr. Bunker, Dean Williams* (branch treasurer), *Jack Raskin*, LHB plating department superintendent, *Earl Arnold*, laboratory chief, and others of the company staff extended themselves to give the AES boys a genuinely sincere welcome.

Preceding the educational and business sessions, members of the branch were escorted on an inspection tour of the LHB plant, warehouse and research laboratories.

Following dinner, Librarian *Ed George* introduced the speaker of the evening, *Earl Arnold*, head of the L. H. Butcher Company's research and laboratory staff. He spoke on the high chloride nickle plating bath, stating that it was one of the developments in the plating industry that has made high speed production possible in both the large plant and the job shop. He illustrated formulae on a blackboard, and thereafter made himself available for questions from the floor.

A business session followed the educational program. *Marcus Rynkofs* moved that the branch recommend that the name of *Frank Rushton* be submitted to the Supreme Society for honorary life membership. The suggestion proved so popular that it was given unanimous approval. Mr. Rushton, who is at present confined to the Military Hospital at Sawtelle, Calif., has been an indefatiguable worker in the interests of the AES for more than 3½ decades. He was the leading spirit in organizing Los Angeles Branch in 1929, and prior to coming to California had been secretary of St. Louis Branch, and had also been active in the affairs of Chicago Branch. His career in plating covered both shop work and direction, shop installation in this country and Mexico, and many years as West Coast manager for the Lasalco Co. of St. Louis, a post which he was compelled to resign several months ago due to illness.

Instructions given to Los Angeles delegates to the national convention included the commission to vote for a new constitution in the form as it was published in a recent issue of *Plating*. *Howard Woodward*, chairman of the annual educational session to be held in March, 1949, recommended the issuance by the branch of a directory-program along the lines of the highly successful one published in 1945. Mr. Woodward was authorized to proceed to do so with the help of a committee to be named by himself.

Walter Behlendorf submitted a proposed budget for regulating branch financial outlays, which the board of managers was instructed to examine prior to its submission for branch approval.

It was voted to hold a picnic for branch members, their families and friends on Sunday, August 1. *Stanley Rynkofs* had done such an excellent job of arranging previously such affairs that he was drafted to handle the current one. A baseball game between teams manned by supply house men and plating shop men will be among the sports items on the program.

Los Angeles Branch will hold no monthly meetings in July and August, resuming on Wednesday, September 8.

Electroplating Institute of America

The Electroplating Institute of America was organized in July 1947 to provide training in the science of Electroplating and to provide the heavy metal industries with an educational

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CUP BRUSH

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STRIPS NICKEL *FASTER, BETTER*

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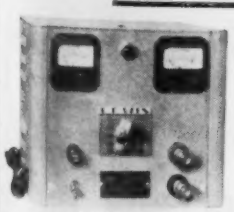
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facility where personnel in the field can be trained.

The school is under the executive management of Mr. Richard J. Zaiden with *Dr. L. E. Lancy* as Technical director.

He is also assisted by an Advisory Board of experts from local organizations, among whom are *William J. Hennessy*, Pennsylvania Salt Manufacturing Co.; *Frank B. Keller*, Standard Steel Spring Co.; *Edwin J. Smith*, Weirton Steel Corp.; *Arthur F. Kaupe*, *J. D. Patrick*, and *A. K. Mock*, Westinghouse Electric Corp.; *G. A. Jersey*, Air Tool Parts and Service Co.; *Richard A. Dimon*, Carnegie-Illinois Steel Corp.; *Edward M. Washburn*, McKinney Manufacturing Co.; *Joseph E.* and *Albert R. Bugel*, East Liberty Electroplating Co.; and *W. B. Williams*, Industrial Lining Engineers.

The courses offered have two objectives in mind: *Electroplating I* is designed especially for students desiring general training in both theory and shop practice of electroplating. This course is a full-time resident one of 9 months duration and comprises 25 clock hours per week; the half-time night course, which is set up especially for persons employed during the day, is of 18 months duration and comprises 12 clock hours per week.

Industrial Electroplating, arranged solely for personnel employed in the plating and allied fields, is offered two nights per week to those members in the industry who are desirous of advancing their technical knowledge and, thereby, enhance their value to themselves and to industry. The classes are conducted by experts from leading local corporations.

All courses are approved by the Pennsylvania Department of Public

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saves labor—time—money on high finishes at high speed

Finish metals including STAINLESS STEEL at 1800 surface feet per minute on flat, convex and concave surfaces.

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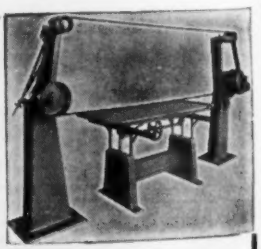

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Instruction and by the Veterans Administration for the training of both veterans and non-veterans alike. They do not require a high school diploma for enrollment.

The first class in Electroplating I was graduated on April 15, 1948 and every student was placed almost immediately. This is attributed, in a large measure, to the fine cooperation prevailing between the school and industry.

National Plastics Exposition

The Third National Plastics Exposition will take place in Grand Central Palace, New York, Sept. 27 to Oct. 1 and will be exclusively a trade and industrial show.

A much larger attendance of business men and prospective buyers may be looked for next fall than at the 1946 and 1947 shows. Admission will be by invitation and registration only. The general public will not be invited. Emphasis will be placed on the trade and industrial side, calling attention to the strides made by the plastics industry in a number of hitherto unexplored fields, with new products, processes, and new and improved machinery.

ASME

James M. Todd to Head American Society of Mechanical Engineers

James M. Todd, New Orleans consulting engineer, today was nominated as the next president of *The American Society of Mechanical Engineers*. His name heads a slate of new officers, including several regional vice-presidents and directors-at-large, submitted by the nominating committee. Nomination is tantamount to election since only one name is presented for each office. Formal election will take place in the fall by letter ballot of the membership, which totals more than 25,000 engineers throughout the United States. The 1948-49 term will begin at the end of the Annual Meeting next December. Mr. Todd, who will succeed *E. G. Bailey* of New York as president of the engineering society, is in private practice as a consulting mechanical and electrical engineer at 217 North Peters Street, New Orleans. Born in Franklin, La., in 1896, he was graduated from Tulane University, New Orleans, in 1918 with the degree of B.E., and in 1930 received the degree of M.E.

During World War I he served in England and France as a lieutenant of engineers. After the war he became chief engineer of *Penick and Ford, Ltd.*, formerly of New Orleans and now of Cedar Rapids, Iowa. Later he was associated with *A. M. Lockett and Co.*, mechanical engineering contractors of New Orleans, resigning to engage in private practice.

Previously he held offices as manager and as vice president of the ASME, and served on many of its important committees.

Other officers nominated are—

As regional vice presidents:

Arthur Roberts, Jr., chief engineer, Lynchburg Foundry Co., Lynchburg, Va.

Forrest Nagler, chief mechanical engineer, Allis-Chalmers Mfg. Co., Milwaukee.

Carl J. Eckhardt, professor of mechanical engineering and superintendent of utilities, University of Texas, Austin.

Albert R. Mumford, development engineer, Combustion Engineering Co., 200 Madison Ave., New York. (Renominated.)

As directors-at-large:

Jacob A. Keeth, manager of power production, Kansas State Power and Light Co., Kansas City, Kansas.

Ralph A. Sherman, assistant director, Battelle Memorial Institute, Columbus, Ohio.

The nominating committee which selected the new slate is headed by *Roland W. Flynn*, division lubrication engineer, Gulf Oil Corp., New York.

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OXIDIZING AGENTS
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Sold in LUMP and LIQUID FORMS by Leading Plater Supply Houses

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Mixtures as Required
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FOR NICKEL PLATING
The one bath especially designed for plating diecastings made of WHITE METAL ALLOYS including ZINC, LEAD, and ALUMINUM. ZIALITE also plates on COPPER, BRASS, and IRON.

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HARD CHROMIUM BATHS
Finer-grained deposits.
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6 times	6.50
Yearly (12 times)	6.00

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1—5000/2500 Ampere, Columbia, 690 RPM.
1—2000/1000 Ampere, H-V-W, 690 RPM.
1—1250/625 Ampere, H-V-W, 850 RPM.
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1—1000/500 Ampere, H-V-W, 1150 RPM
8—125 Ampere, Hobart, 6 volts.

12/24 Volts

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1—6000/3000 Ampere, Chandeysson synch. M.D., 400 RPM.

15 to 25 Volts

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1—1000 Ampere, 15 V. Gen. Elec.
1—300 Ampere, 15 V. Star.
3—1500 Ampere, 20 V. Elec. Prods.
2—3000 Ampere, 20 V. Elec. Prods.
1—800 Ampere, 22/33 V. Gen. Elec.
1—1500 Ampere, 24 V. Elec. Prods.
1—600 Ampere, 24 V. Reliance.
1—200 Ampere, 25 V. Star.
1—1000 Ampere, 25/35 V. Diehl.
1—300 Ampere, 25 V. Star.
1—175 Ampere, 25 V. Cr. Wh.

32 to 60 Volts

1—500 Ampere, 32 V. Columbia.
2—100 Ampere, 30 V. Gen. Elec.
1—200 Ampere, 30 V. West.
2—200 Ampere, 32 V. Gen. Elec.
2—1500 Ampere, 32/40 V. Elec. Prods.
1—1000 Ampere, 33 V. Gen. Elec.
2—200 Ampere, 42 V. Gen. Elec.
3—1500 Ampere, 45 V. Century.
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1—400 Ampere, 50 V. Gen. Elec.
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1 Chandeysson 6000/3000 amperes @ 3½/7 V.
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